

EFFECTS OF SIZE AND SHAPE ON THERMODYNAMIC PROPERTIES OF NANOMATERIALS

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ABSTRACT

A simple model based on the cohesive energy of the Nano-material has been used to study the size dependence of Debye temperature and Young's modulus of Au, Ag, Ni and Pb nanomaterials. It is noted that the Debye temperature and the Young modulus both decreases with particle size of different shapes of nanomaterials. The results obtained were compared with available experimental data to determine the accuracy of the model. A good agreement between the theoretical model and experimental data is observed for the Debye temperature and Young's modulus for the considered nanomaterials.

Keywords: Nanomaterials, Young Modulus, Debye Temperature

I. INTRODUCTION

The idea of nanotechnology first appeared in the famous talk "there is plenty of room at the bottom." Given by the physicist Richard Feynman at the American Physical Society meeting at Caltech on December 29, 1959. Feynman anticipated and described a process by which scientists would acquire the ability to manipulate materials at a nanoscale, and indeed he was right because here we are the 21st century doing just that. The term nanotechnology was originally defined by Norio Taniguchi in 1974 as follows: "nanotechnology mainly consists of the processing of separation, consolidation and deformation of materials by one atom or by one molecule." Nanotechnology and nanoscience began in the early 1980's with the advances in computing power and material modeling. Nanomaterials are basically the link between nanoscience and nanotechnology. Nanomaterials generally deal with sizes less than 100nm [1].

According to Roduner, E. (2006), a small sample of gold has quite different properties from the ordinary gold we know. At 10nm, it is no longer shiny and yellow but instead it absorbs green light and appears red. It's melting temperature decreases drastically as size is decreased and it ceases to be noble. So, it is safe to say that elements we know are totally different at nanoscale, hence the birth of words such as nanomaterials, nanotechnology and nanoscience. This project is centered on the Debye temperature, but we will also include other nanomaterial properties briefly in this introduction. The Debye temperature $\theta_D(r)$ has received considerable attention because it is an essential property to characterize many materials properties such as thermal vibration of atoms and phase transitions. Furthermore, other important physical properties and their size-dependence such as the Einstein temperature $\theta_E(r)$ and volume thermal expansion coefficient $\alpha_v(r)$ are related to the Debye temperature. Thus once the Debye temperature is known, the others can be determined

from it. [3] There is a spectrum of frequencies that atoms in a crystal can assume, and the maximum frequency that the atoms can assume is called the Debye frequency. The Debye frequency can be attributed to a certain maximum temperature that can be achieved due to a single normal vibration and that is the Debye temperature given by:

$$\theta_D = \frac{h \nu_m}{K_B} \quad (1)$$

Where h is the Planck's constant. K is the Boltzmann constant, ν_m is the Debye frequency

The results so far suggest show that the Debye temperature increases with increasing radius. [4]. A lot of experimental and theoretical studies have been conducted concerning effect of size on thermodynamic properties of nanomaterials. A theoretical study of size dependence of cohesive energy for Ag, Co, Al and Cu nanoparticles was conducted by Zhu et al. Cottie carried out the study of melting temperature and its dependence on size for Au Nano-crystalline. Olson et al on the other hand studied the size dependence of melting temperature of Bi Nano-film. Liang et al studied the size dependence of elastic modulus of Cu and Au thin films [5]. Numerous studies have focused on the measurement of melting temperature $T_m(r)$ since Takagi first observed the size-dependence of melting temperature for metallic nanoparticles. The methods used to measure T_m include: electron diffraction, particle shape change, and dark field image, scanning Nano-calorimetry, in situ X-ray diffraction and many more. The results showed that T_m decreases with decreasing r for isolated Nano-solids with free surfaces, which is called "undercooling" as opposed to thermodynamic "superheating". Couchman & Jesser suggest that melting of small particles is a liquid nucleation and growth process. With melting beginning by nucleation of liquid at the surface and the liquid nucleus moves into the solid with an activation energy. [4]. A size-dependent elastic properties study for ZnO nanowires by Hu, J. Liu, W. & Pan, B.C. showed that total energy of nanowires increase as the radius decreases and that the total energy is higher than that of bulk ZnO. Implying that smaller nanowires are less stable. The study also showed that Young's modulus increases monotonically as the radius decreases. Furthermore, when the size of a ZnO nanowire becomes large enough, its Young's modulus should approach the bulk value. However the fact that values of Young's modulus are higher than the bulk value suggests that the ZnO nanowires are stiffer than the bulk ZnO. However this can only be seen at the surface, meaning as we go inside the nanowire wire it becomes softer than the surface. Hu concluded that this was caused by the compressive strain of the surfaces and that the softening of the interior layers has stemmed from their tensile strain.

With the development of nanoscience and nanotechnology in recent years, size of materials come into nanometer size range (<100nm) at least in one dimension. This leads to dramatic increase of surface/volume ratio and corresponding changes of physical, chemical and mechanical properties. It is very important to understand these properties and their related physical basis for correct industrial application.

With that being said, the purpose of the project is to determine the Debye temperature and Young's modulus of the nanomaterials which is based upon the cohesive energy of the nonmaterial. For that I studied the equation of states for the size dependent Debye temperature of the following nanomaterials: Au, Ag, Ni and Pb. This will be carried out for spherical nanosolid, nanowire and nanofilm. The results will then be compared to experimental data in order to determine the accuracy of the model used. The idea behind this research is to provide better understanding of properties of nanomaterials for optimum application and to make an addition on the existing literature regarding the subject of nanomaterials and their properties.

II. THEORETICAL MODEL

The cohesive energy of the nanomaterials is the sum of energy due to the contributions of the interior atoms and the surface atoms, which is expressed as

$$E_{sum} = E_0(n - N) + \frac{1}{2} E_0 N \quad (2)$$

Where n is the total number of atoms of Nano-solids and the number of its surface atoms is N .

Therefore, $(n - N)$ is the total number of interiors atoms of the Nano-materials. E_0 Is the cohesive energy of the bulk materials per atom. Eq. (1) may be written as

$$E_p = E_b \left(1 - \frac{N}{2n}\right), \quad (3)$$

Where E_p is the cohesive energy per mole of the nanomaterials, which is given by $\frac{AE_{sum}}{n}$, here, A is the Avogadro constant. E_b is defined as the cohesive energy per mole of the corresponding bulk materials which is given by $E_b = AE_0$.

The relation between the melting point of nanomaterials and bulk are reported as:

$$T_p = T_b \left(1 - \frac{N}{2n}\right) \quad (4)$$

The elastic moduli increase by increasing the cohesive energy. The relation for elastic moduli can be written as

$$B_p = B_b \left(1 - \frac{N}{2n}\right) \quad (5)$$

And

$$Y_p = Y_b \left(1 - \frac{N}{2n}\right) \quad (6)$$

One may get the connection between the melting point and the Debye temperature from the Lindemann's comparative. According to this a crystal will melt when the root mean square displacement of an atom exceeds a certain fraction of the interatomic distance in the crystal. Relating the specific heat theory with the Lindemann's melting formula, the characteristic temperature square is proportional to the melting point of the crystal. So, the Debye temperature for the bulk material is inscribed as

$$\theta_b^2 \propto \left(\frac{T_b}{MV^{2/3}}\right), \quad (7)$$

Similarly, for nanomaterial

$$\theta_p^2 \propto \left(\frac{T_p}{MV^{2/3}}\right), \quad (8)$$

Where, M is the molecular mass.

Equation (7) and (8) give the following relation we get

$$\left(\frac{\theta_p^2}{\theta_b^2}\right) = \frac{T_p}{T_b} \quad (9)$$

One can derive the relation for α_p , which is recited as

$$\alpha_p = \alpha_b \left(1 - \frac{N}{2n}\right)^{-1} \quad (10)$$

Therefore, from Eq. (5) and (6) we acquire

$$\left(\frac{\theta_p}{\theta_b}\right) = \left(1 - \frac{N}{2n}\right)^{1/2} \quad (11)$$

Where, N is the total number of surface atoms and n is the total number of Nano-solids. α_b is coefficient of volume thermal expansion of bulk material. The surface atoms refer to the first layer of the Nano-solid. The method to find $N/2n$ for different shape of nanomaterials has been calculated. The value of $\frac{N}{n}$ is $\frac{4d}{D}$, $\frac{8d}{3l}$ and $\frac{4d}{3h}$ for spherical Nano-solids, nanowires and Nano-films respectively. Where, d is the diameter of Nano-solid and D is the diameter of the spherical Nano-solids. l and h are the diameter of nanowire and height of the Nano-film correspondingly.

Table 1. Input Parameters

Nano-material	Atomic diameter (d nm)
Au	0.3189
Pb	0.3869
Ni	0.2751
Ag	0.319

III. RESULTS AND DISCUSSION

From the figures we can see that Young's modulus, specifically the ratio increases. The graph can be divided into two parts, which are sizes less than 10nm (D, L, H < 10) and sizes greater than 10nm (D, L, H > 10) [6]. There is a drastic change in Young's modulus for sizes less than 10nm but there is a gentle change, which tends to be constant for bigger sizes. The drastic change can be attributed to surface area and volume ration, which is given by:

$$\frac{A}{V} = \frac{3}{r} \quad (16)$$

Where r is the radius of the sphere for spherical Nano-solid. The r can be replaced by L or H for nanowire and Nano-film respectively. Most of the physical properties of nanomaterials are a result of high surface area to volume ratio. From equation (5) it can be seen that the ratio decreases as r increases, and if r is very large the

ratio become very small. Thus when $D, L, H < 10\text{nm}$, the area to volume ratio is larger hence the drastic increase in Young's modulus. For $D, L, H > 10\text{nm}$, the area to volume ratio is decreasing hence the gentle increases of Young's modulus, which becomes a constant for very large r values.

This is because at very large r values, the influence of the area to volume is negligible if not zero and the materials have now shifted from being nanomaterials to ordinary bulk materials.

A study conducted by Patil, S.D et al (2014), which involved effect of size and shape on Young's modulus by Lindeman's criterion show rather opposite results to ours. He did use a different model given by:

$$\frac{Y_n(r)}{Y_b(\infty)} = \exp \left[\pm (\alpha - 1) / (r/r_0 - 1) \right] \quad (17)$$

Which lead me to believe that Young's modulus does not show a universal trend with particle size as the literature shows. That perhaps the variation trend depends strongly on the application conditions.

Another study by Dabhi, S. & Jha, P.K. which is very similar to ours used the same model for Young's modulus, given by:

$$Y_n = Y_b \left(1 \pm \frac{N}{2n} \right) \quad (18)$$

Where they explained that the positive and negative signs are the representation of orientations. Meaning the plus or minus sign can go either way, because for our study we used the minus sign. According to Dabhi, S. & Jha, P.K. recent studies on mechanical properties with size for TiO_2 , SnO_2 and CeO_2 do not reach to a universal conclusion regarding the size dependency of Young's modulus in these compound despite their possible uses in Nano-electric systems and resistance based gas sensors as active components. This shows that the mechanism for size dependency of Young's modulus in 1D nanomaterials is not well understood and a systematic effort is desired [8]. From the figures, Debye temperature follows the same general trend as the Young's modulus. Meaning Debye temperature increases as particles size increases. The graph still exhibits two parts, $D, L, H < 10\text{nm}$ and $D, L, H > 10\text{nm}$. Similarly these parts can be attributed to surface area to volume ratio like with Young's modulus. The only difference is that the graph for Debye temperature is much steeper than that of Young's modulus. Perhaps this is because the Debye temperature is much more sensitive to change in surface area to volume ratio.

Unlike the Young's modulus, all the studies I reviewed showed similar results for Debye temperature, thus the Debye temperature is bit a sure thing than the Young's modulus. The experimental results for Au thin films are included and as it can be seen there is a very good agreement between our models results and the experimental results.

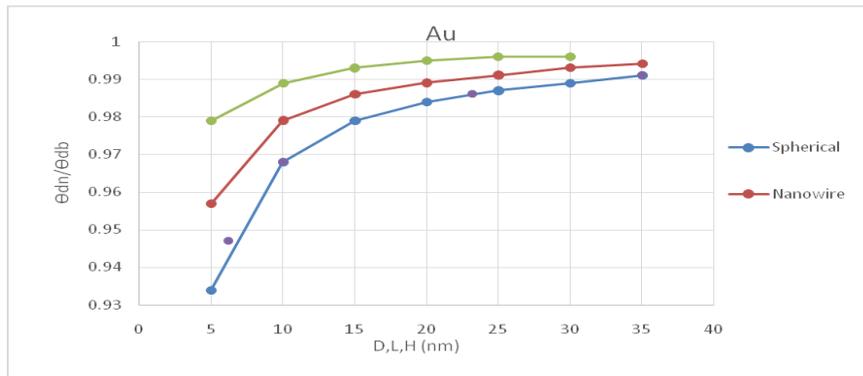


Fig.3 Size Dependence of the Ratio of Debye Temperature for Au Nano-Particle

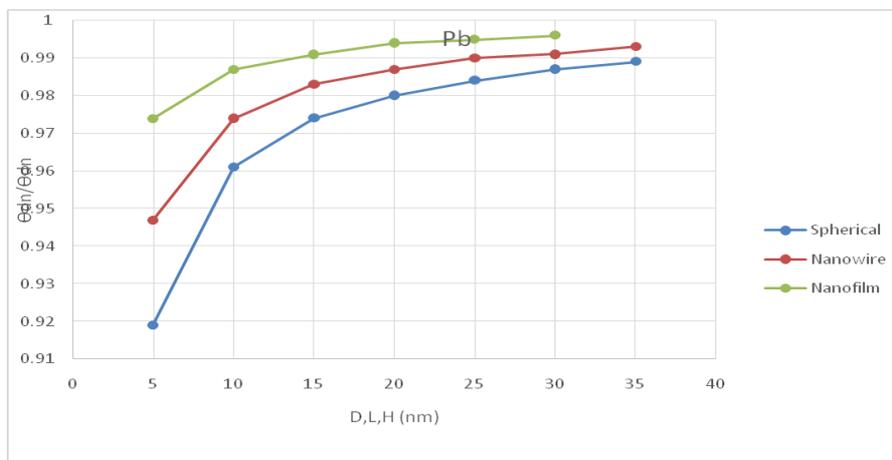


Fig.4. Size Dependence of Debye Temperature Ratio for Pb Nano-Particle

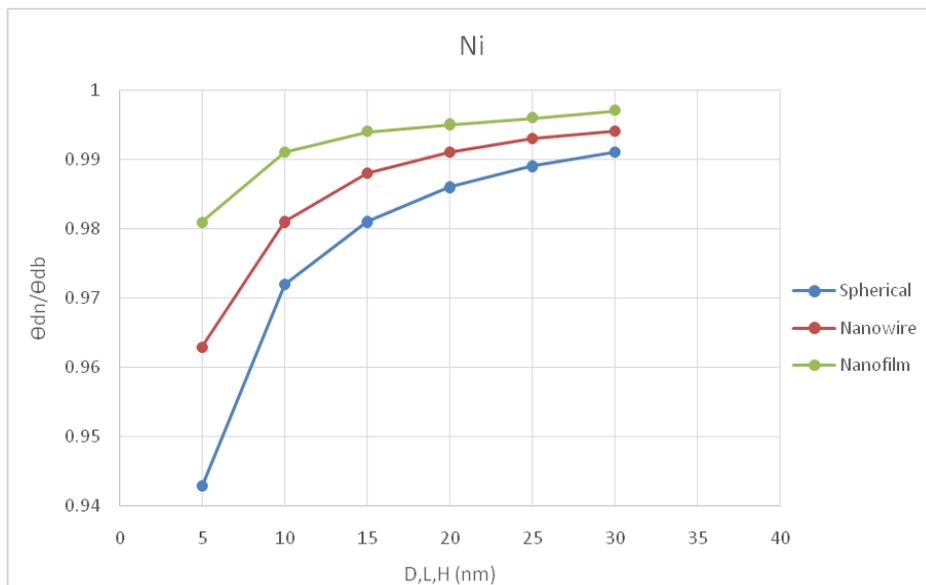


Fig.5. Size Dependence of Debye Temperature Ratio for Ni Nano-Particle

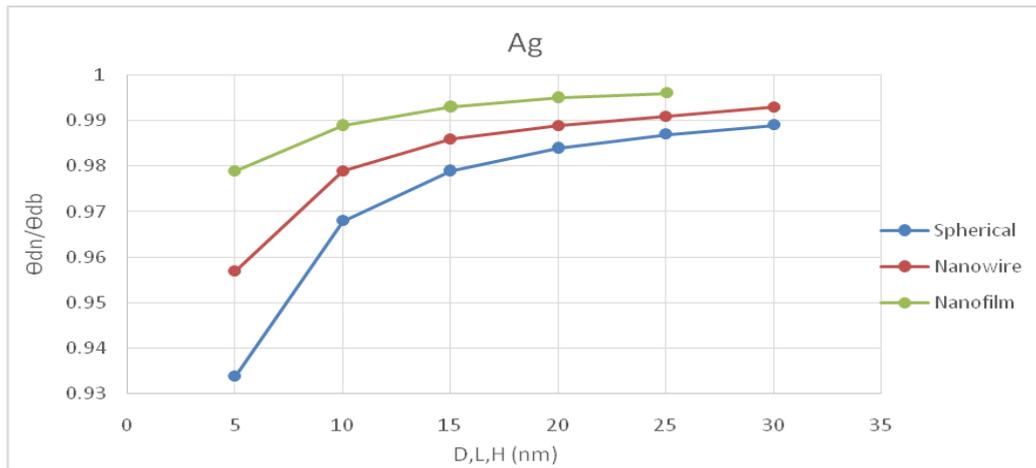


Fig.6. Size Dependence of Debye Temperature Ratio for Ag Nano-Particle

Young's modulus

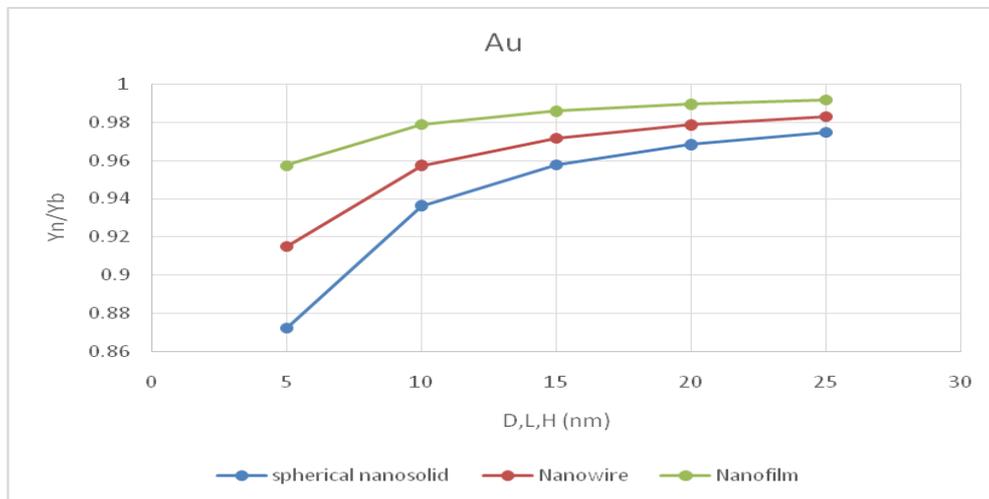


Fig.7. Size Dependence of the Young's Modulus Ratio for Au Nano-Material

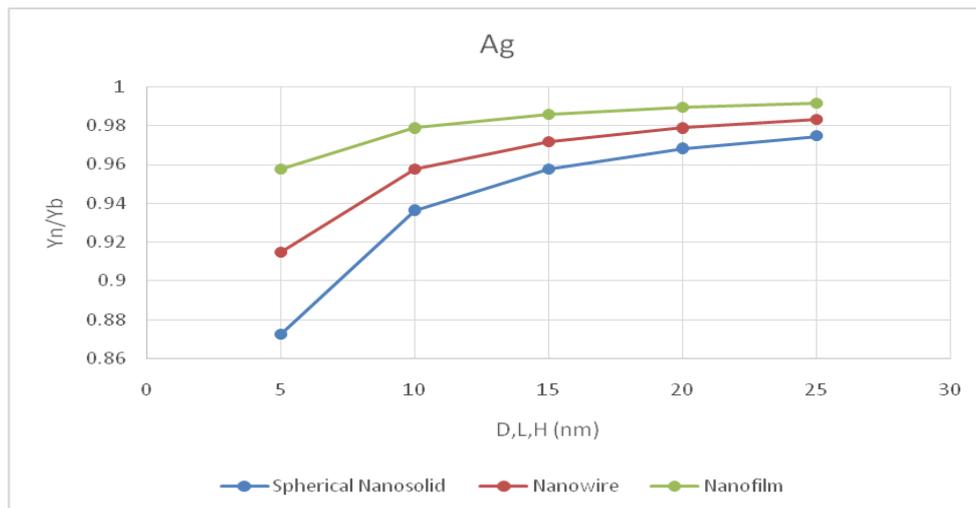


Fig.8. Size Dependence of Young's Modulus Ratio for Ag Nano-Material

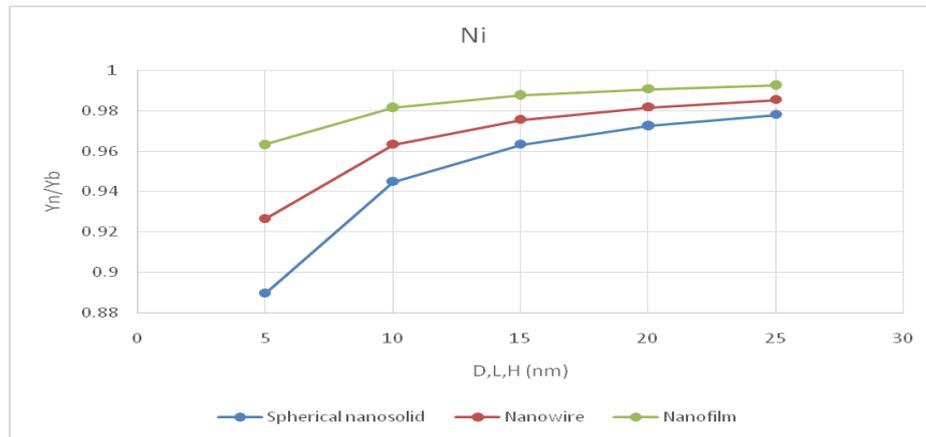


Fig.9. Size Dependence of Young's Modulus Ratio for Ni Nano-Material

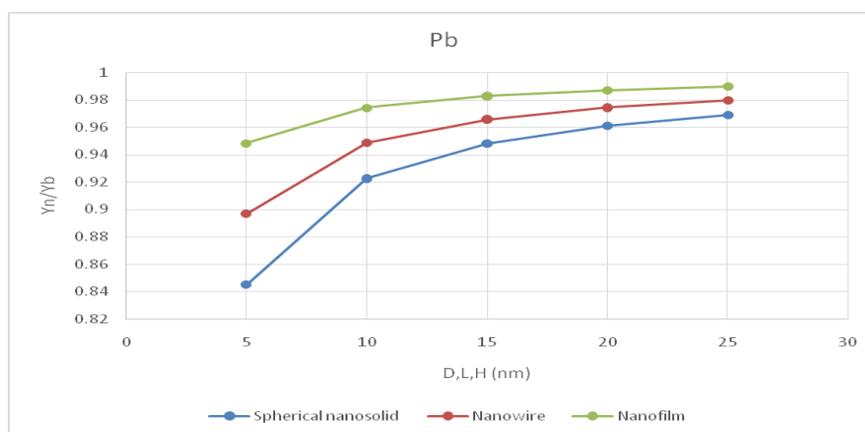


Fig.10. Size Dependence of Young's Modulus Ratio for Pb Nano-Material

IV. CONCLUSION

In conclusion, both the ratio of Young's modulus and Debye temperature ratio increases with increasing particle size. However, both the graphs of Young's modulus and Debye temperature can be divided into two parts ($D, L, H < 10\text{nm}$ & $D, L, H > 10\text{nm}$). For $D, L, H < 10\text{nm}$ the two properties show rapid increase with increasing size and for $D, L, H > 10\text{nm}$ the increase is gentle until it becomes a constant at very large atomic sizes.

REFERENCES

- [1] Guisbiers, G. Nano Express, 2010, 1132
- [2] Roduner, E. Chemical Society Reviews, 2006, 35, 583
- [3] Zhao, M. & Jiang, Q. Key Engineering Materials vol.444, 2010, 189-217
- [4] Yang, CC. & Mai, Y. Materials Science and Engineering R 79,2014, 1-40
- [5] Bhatt, J & Kholia, K. Indian Journal of pure & applied physics vol.52, 2014, 604-608
- [6] Patil, S.D., Shinde, P.B., & Takale, M.V. International Journal of Chemical and Physical Sciences vol.3, 2014, 152
- [7] Gleiter, H. Acta mater. 48, 2000, 1-29
- [8] Dabhi, S. & Jha, K. Advanced Science, Engineering and Medicine Vol. 6, 2014, 1-4

ENTERPRISE RISK MANAGEMENT IN FMCG SECTOR

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“We have developed a proactive approach for mitigating risks by conducting detailed hazard identification and risk assessment exercises and adopting control measures for high risk areas.” **Dabur India Limited**

I. INTRODUCTION

1.1 Fmcg

The term Fast-moving consumer goods (FMCG) was coined by Neil H. Borden in his work named 'The Concept of the Marketing Mix' in the year 1965. (1996 , Prentice-Hall, Inc.)

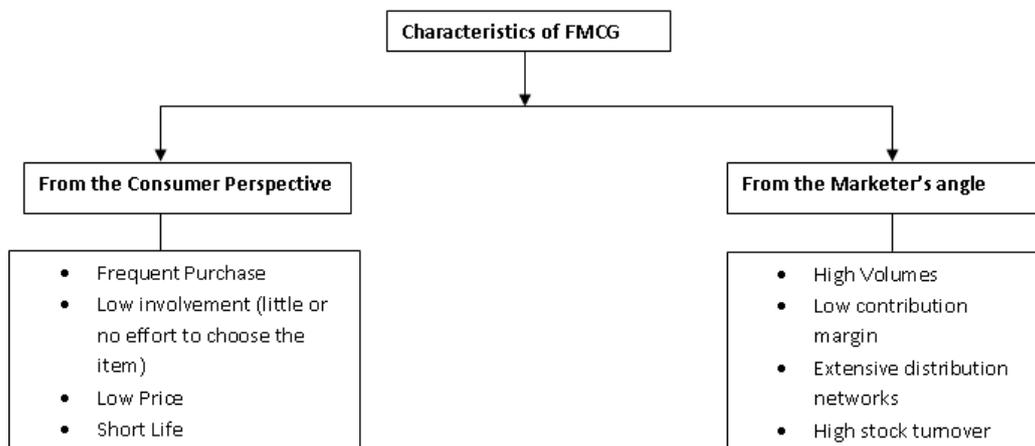
Fast-moving consumer goods (FMCG) or consumer packaged goods (CPG) are products that are sold quickly and at reasonably low cost. Examples of some FMCG non-durable goods are : soft drinks, over-the-counter drugs, toys, toiletries, processed foods and abundant other consumables.

FMCG have a short shelf life either due to high consumer demand or because the product deteriorates (perishes) quickly. Some FMCGs such as meat, fruits, vegetables, dairy products and baked goods are highly perishable. Other goods such as alcohol, toiletries, pre-packaged foods, soft drinks, and cleaning products comparatively have long time utility.

Though the profit margin per unit made on a FMCG product is relatively small (more so for retailers than the producers/suppliers), they are usually sold in huge quantities. Thus the collective profit on such goods can be substantial. FMCG is probably a typical case of low margin and high volume business.

Major Indian Fast-Moving Consumer Goods (FMCG) companies, includes subsidiaries of multinational FMCG firms that are listed in India are : Hindustan Unilever, ITC Ltd., Pidlite Industries, Amul, Godrej Consumer Products Limited, Dabur India Ltd, Emami, Colgate Palmolive India Ltd., Zydus Wellness, Britannia, GlaxoSmithKline Consumer Healthcare Ltd. (India), Wipro Consumer Care & Lighting Ltd., Marico, Future Consumer Enterprises Ltd., CavinKare' Parle Agro' Jyothy Laboratories, Haldiram's, Nirma , Himalaya Healthcare Ltd., Bikanervalva, Nestle

The following are the main characteristics of FMCGs:



II. RISKS TO FMCG SECTOR

Like the other sectors, the **FMCG sector is also subject to varied business risks** like:

- Intense competition,
- Unpredictable monsoons,
- Rapid shift in consumer tastes and preferences
- Unstable commodity prices.

The evaluation of risks being faced by FMCG entity need to be assessed in consonance to its specific vulnerability(s). Enterprise Risk Management (ERM) has a crucial and decisive role to play here.

Three great and leading FMCG majors companies in the country have been selected for this article with consistently stellar performance, over the years. They are Hindustan Unilever Limited (HUL), Nestlé India Limited (NIL) and Dabur India Limited (DIL).

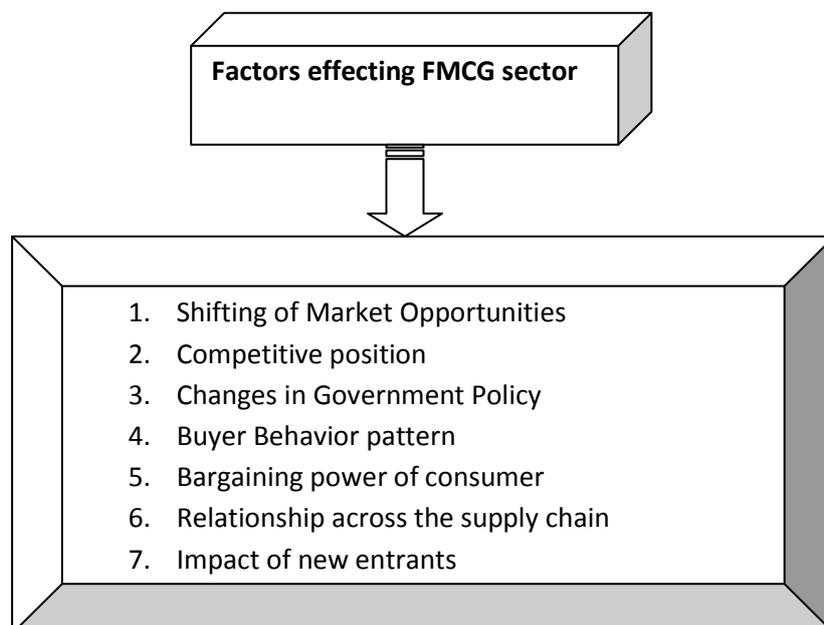
HUL is India's largest FMCG Company with a legacy of about 80 years in India and touches the lives of two out of three Indians.

NIL is a subsidiary of Nestlé S.A. of Switzerland – the world's leading Nutrition, Health and Wellness company. DIL is a leading India-born FMCG company.

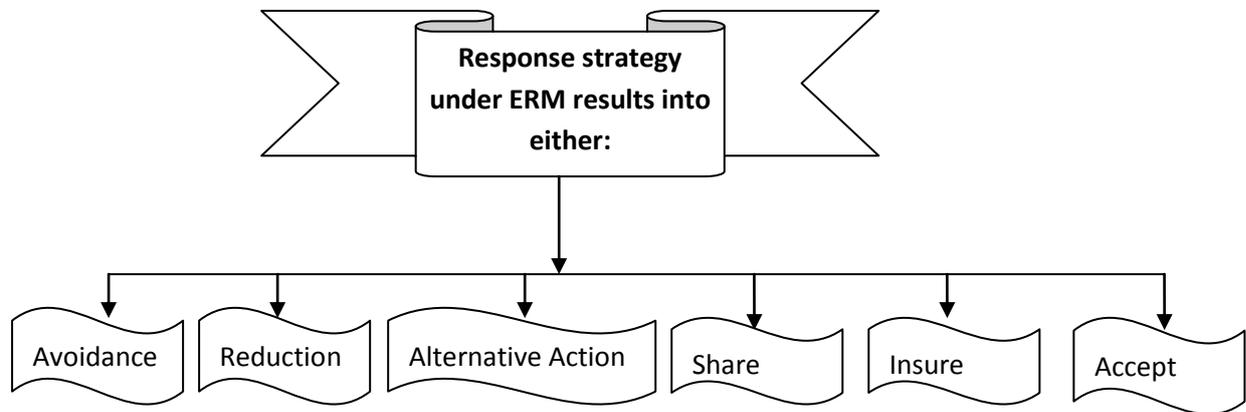
Environmental risk can have serious harmful effects on an organization's financial well being and its ability to achieve its business objectives and FMCG's are not an exception. Existing and forthcoming legislation and regulations as well as governance and accounting trends of environmental risk and liability can influence an organization's financial performance, reputation and brand, cash flow, and shareholder value. Corporations and their directors and officers are at increasing and continuous risk of facing criminal allegations and serious financial penalties imposed for not properly attending to environmental issues.

III. Risk Mitigation in FMCG Sector

The risks for an FMCG organization emanate from various sources and influence different aspects of the organization. The intensity, quantum, the value or loss due to the risk may be affected by the following factors:



Identification of the risks necessitates a comprehensive knowledge of the aims, objectives and operations of the organisation. One must also have an idea about the business environment be it political, legal, social, cultural or market conditions that it operates in. After recognition and analysis of the concerned risks their impact and likelihood are determined. Finally a suitable response strategy is charted out to suit the organization.



The success of ERM is highlighted by the reduction in the probability or impact of the concerned threat. These threats at times bring opportunities for the firms.

IV. HINDUSTAN UNILEVER LIMITED (HIL)

HUL is India's major FMCG Company with a heritage of about 80 years in India. HUL touches the lives of two out of three Indians. It owns some of the best-known and best-loved brands like Dove, Surf, Kissan, Bru and Pureit.

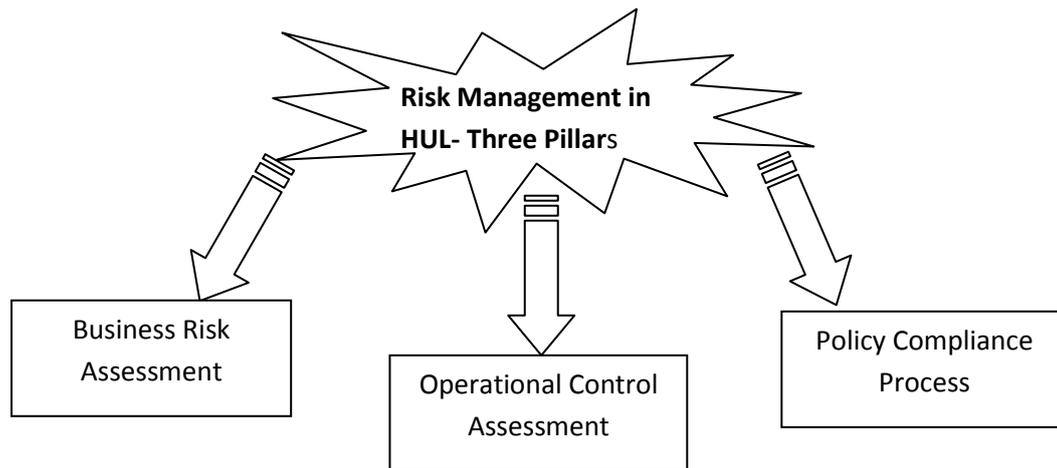
HUL has build its brand and developed products after extensive consumer surveys, constant innovation, and crystal-clear designing and marketing. HUL is devoted to promoting sustainable living. It has adopted new ways of doing business that help to reduce carbon footprint on one side and brings positive social impact on the other.

Examples of HUL initiatives:

1. **Reduce waste, costs and risks** -By reducing waste HUL creates efficiencies and reduces costs. This in turn helps to improve margins.
2. **Sustainable production activities**- HUL aims to develop more sustainable ways of developing products, sourcing and manufacturing. This opens up opportunities for innovation while improving the livelihoods of the suppliers.

4.1 Risk Management in HUL

HUL has detailed Risk Management procedure, which is based on three pillars: Business Risk Assessment, Operational Controls Assessment and Policy Compliance processes. The Company has a well-built internal audit, corporate risk assessment and mitigation system. It has an independent Control Assurance Department (CAD) supported by dedicated audit teams.



4.2 Business Risk Assessment

Business Risk Assessment procedures are in place for self-assessment of business risks, operating controls and compliance with Corporate Policies. Tracking the evolution of risks is a continuing process and it ends up in development of mitigation action plans.

A number of the risks relate to competitive intensity, others to buyer behavior, environmental changes and some to cost volatility. Major risks are identified and then systematically handled by mitigating actions on a continuing basis.

4.3 Internal Controls

The Company's internal control systems correspond to the nature of its business and the size and complexity of its operations. These are routinely tested and certified by the Statutory as well as Internal Auditors. Significant audit observations and follow up actions thereon are reported to the Audit Committee.

Further the Audit Committee reviews adequacy and effectiveness of the Company's internal control environment and monitors the implementation of audit recommendations, including those relating to strengthening of the Company's risk management policies and systems.

The Internal Audit covers all the factories, sales offices, warehouses and centrally controlled businesses and functions, according to the annual plan agreed with the Audit Committee. The audit coverage plan of CAD is approved by the Audit Committee at the beginning of the year. Every quarter, the Audit Committee of the Board is offered with key control issues and action taken report on the issues highlighted in previous report.

4.4 Financial Controls

Financial controls review and assessment procedures and guidelines are issued by Unilever annually in line with Sarbanes-Oxley (S. 404) requirements. Unit heads are responsible for implementing these procedures to confirm the effectiveness of the financial controls in that unit and to correct any instances of weaknesses identified. In addition the unit heads, review the effectiveness of operational and non-financial controls. Financial control environment is streamlined and strengthened with 50% of key controls being mechanized by using SAP. These procedures provide the management an assurance on the internal processes and systems.

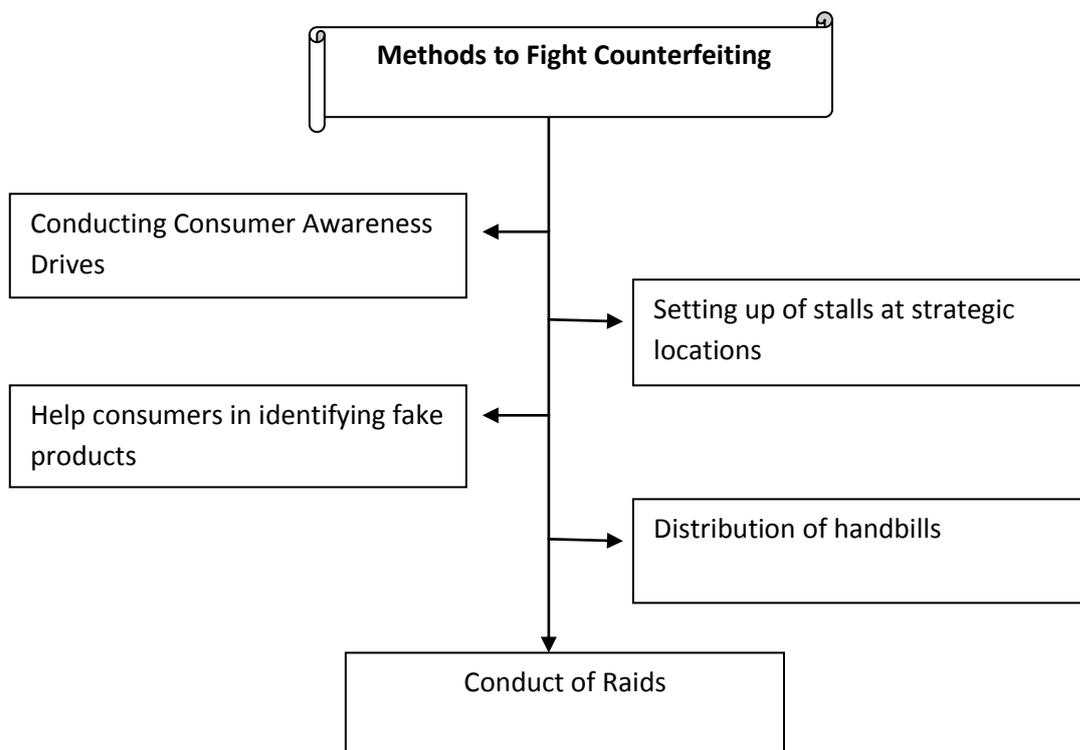
HUL manages cash and cash flow processes involving all parts of the business very diligently. On 31st March, 2014 it had a net cash surplus of Rs. 2,220.97 crores. The Company's low debt equity ratio provides ample scope for gearing the Balance Sheet if needed.

Foreign Exchange transactions exposure is also fully covered with strict limits placed on the amount and there are very small amount of uncovered exchange rate risks in regard to company's imports and exports.

4.5 Management of Environment and Climate Change Risk

In November 2010, HUL's parent Unilever launched the Sustainable Living Plan. It's vision is to double the size of its business while reducing the overall impact on environment. HUL's operations at every unit support this great ambition. By the end of 2011, almost two-thirds of the palm oil used in the products worldwide was procured from sustainable sources. In India, 60% of tomatoes used by HUL are sourced from sustainable sources.

4.6 Management of Evils of Counterfeiting



FMCG business is a high volume and low margin business by nature and seeks to cater to every individual across geographies. It is highly subjected to the threat of counterfeits and look-alikes. Especially people in low literacy zones accept duplicate products. These fraudulent products, through their poor and often harmful properties, have the potential of 'putting off' customers from the original brand altogether.

To fight the danger of counterfeits, HUL frequently carries out consumer awareness drives. Notable among them is the setting up of stalls at strategic locations with tons of counterfeit products to help consumers identify fake products and realize their health-hazards.

Handbills to educate consumers about the harms of counterfeited products are distributed by HUL with the support of government and non-government agencies.

Raids are conducted in factories and bottling units in the past where large scale duplications are expected.

V. NESTLE INDIA LIMITED (NIL)

NIL is a subsidiary of Nestle S.A. of Switzerland .It is the world's foremost Nutrition, Health and Wellness company. It has over 283,000 employees. It has operations in almost every country in the world. It's portfolio covers practically all food and beverage categories with market leaders like Nestle, DRUMSTICK, NESCAFE, STOUFFERS, KITKAT, Nestle GOODSTART, Nestle PURE LIFE and PURINA , to name a few.

According to Nestle ".....risks are not obvious but their effects are, hence the need for Best practice to avoid failure....."

Nestle's Risk Management Centre was created in early 2001. It aims to coordinate activities related to risk management in the areas of Quality, Security, Treasury, Compliance, Operations, and IT etc.

Further NIL adopted a safety engagement programme – "Safe by Choice" in partnership with leading safety consultants DuPont. The purpose was to develop and nurture high safety standards at various locations of the Company. In 2010, NIL rolled out "Responsible Sourcing Programme" for its select vendors under Nestle Environment Management System.

VI. ENTERPRISE RISK MANAGEMENT

Nestle has worked out an appropriate risk management process which has a material impact on Nestle's business. Enterprise Risk Management process consists of steps like:

- Anticipation of risks
- Loss Prevention like : fire, natural and safety
- Prevent: Business Continuity Management plan and
- Risk Financing: risk retention, risk transfer and claims management.

Risk management process at Nestle highlights most relevant business risks; supports cross-fertilization between diverse businesses; provides relevant information for management change; helps to focus only on relevant risks, functional support helps keeping processes efficient and practical.

VII. ERM AT DABUR INDIA LIMITED (DIL)

DIL is a leading India-born FMCG company.

Dabur's business activities are also subject to risks that every Fast Moving Consumer Goods (FMCG) company faces today.

The company in order to achieve its wider business objectives has institutionalized 'Dabur Risk Management Framework' .

It aims to :

- ❖ Identify the business risks that surround each function or area of operation and
- ❖ Assist the company-wide process of managing such risks,

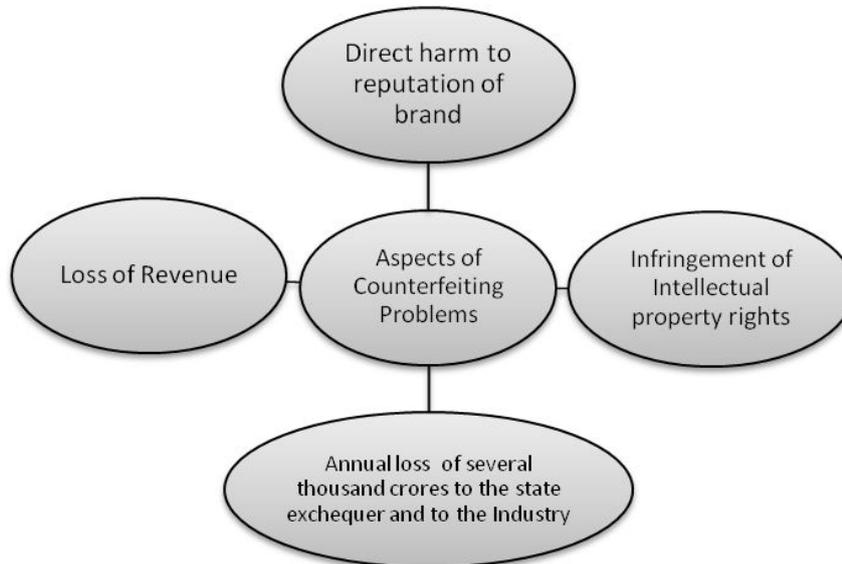
Further, being in the Herbal/Ayurvedic segment, Dabur is completely aware that some risks it faces are somewhat different to those that generally exist in the FMCG business.

Dabur has developed a hands-on approach for mitigating risks by conducting detailed hazard identification and risk assessment exercises and adopting control measures for high risk areas.

DIL's portfolio of Ayurvedic and nature-based products makes it essential for the Company to earnestly pursue the conservation of natural resources and follow its sustainability program.

DIL, as a part of its risk management and mitigation process has also set up greenhouses to grow rare herbs and medicinal plants, besides working with farmers to cultivate such herbs.

VIII. COUNTERFEIT (FAKE) PRODUCTS



Counterfeiting creates an economic concern for the industry . It results in infringement of intellectual property rights, loss of revenue and direct harm to reputation of the brand.

Since people engaged in the manufacturing of bogus products do not adhere to any quality checks and use spurious raw materials, these counterfeit products may affect consumer’s health. This in turn leads to serious damage to the product’s brand equity.

Besides this counterfeit products are also causing an annual loss of several thousand crores to the state exchequer and to the industry. An independent Assoc ham survey had recently stated that globally the trade in counterfeit and pirated goods cost the economy \$650 billion annually. This segment roughly represents 9% of the total world trade. Fake products market in India results in an annual loss of Rs 15,000 crore to the government exchequer and FMCG industry loses approximately Rs 8,000 crore yearly.

IX. DABUR’S RESPONSE TO COUNTERFEITING PROBLEMS

- ❖ Dabur has been targeting fake products & packaging manufacturers and label printers in a planned manner.
- ❖ In the last one year several raids by local authorities were done which have resulted in seizure of counterfeit goods worth several crores of rupees.
- ❖ Dabur maps out the locations where these activities take place and then systematically handles spurious products manufacturers.
- ❖ Leads are obtained on packaging and label suppliers as well.
- ❖ Dabur works closely with a number of organizations and sleuths to track alleged counterfeiters and identify illegal networks.
- ❖ Dabur is also a member of the recently formed FICCI CASCADE Committee, which works for creating awareness on the threat of smuggled goods and counterfeit products. This committee holds meetings with Government officials to garner their support for this initiative. The Committee has also joined hands with

the Department of Consumer Affairs for inclusion of counterfeit goods problem in their 'Jago Grahak Jago' campaign.

- ❖ Help of Central Board of Excise & Customs and the Economic Offence Wing, Delhi Police, is also sought in addressing this issue.

X. RISK OF CLIMATE CHANGE / ENVIRONMENTAL DEGRADATION AND DABUR'S RESPONSE

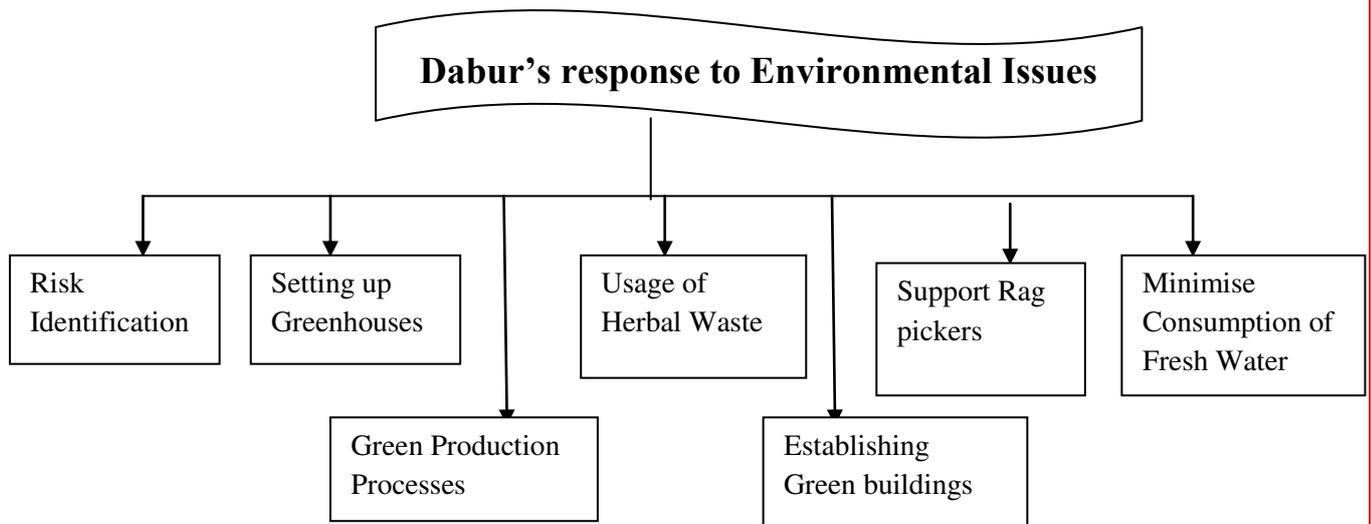
At Dabur, environment and nature are considered the lifeline of its business as many of Dabur's products are dependent on agricultural inputs. Disruptions in agricultural patterns and yields are significant potential risks arising out of climate change.

Conservation of nature and natural resources is deep rooted in Dabur's organisational DNA, and in every aspect of business.

10.1 Dabur's Response

Dabur values nature's bounty as without the fruits of nature, the vision of Dabur – dedicated to Health & Well-being of every household would never have been fulfilled. For this reason it has an unflinching commitment to ecological conservation and regeneration.

Dabur's response to environmental issues is multi-pronged and includes:



1. Identifying and evaluating climate change risks for each business.
2. Setting up Greenhouses to grow rare herbs and medicinal plants, besides working with farmers to cultivate such herbs. This initiative has transformed the lives of farmers across the country and even in Nepal, and improved their livelihood.
3. Reducing the environmental impact of production processes & products and work towards creating a positive environmental footprint.
4. Reducing energy consumption by using herbal waste as fuel .
5. Establishing green building and manufacturing units, which are not just LEED certified but also have set high standards in water conservation and herbal waste recycling.
6. Dabur also works with its packaging suppliers and engages rag-pickers to pick up waste from the streets and city dumps, recycle them to create various products like office stationery and roofing sheets.

7. Besides constantly minimizing the consumption of fresh water at its Units, Dabur has also created rainwater-harvesting facilities at its units.

XI. EMPLOYEE SAFETY RISK

A manufacturing concern constantly faces risks related to accidents and health hazards of the workers. Management of Dabur recognizes its employees as the company's most important assets. Dabur aims to achieve the target of zero accidents within its factory premises. It is committed to abide by a Policy of Prevention and Elimination of all undesirable incidents.

Dabur has introduced a number of safety measures across all its manufacturing units. It continuously works towards achieving international benchmarks in safety standards. And this is demonstrated by the fact that Dabur has not reported any High Potential Accident so far.

Dabur has been a part of National Safety Meet with Health, Safety and Environment (HSE) and designed Improvement Plans at production level too. Dabur is also committed to get all its operational locations certified with the Integrated Management System OHSAS 18001 and ISO 14001 — Occupational Health, Safety and Environment.

Dabur has also taken an insurance policy on Occupational Health, Safety and Environment to mitigate the financial loss and its liability thereupon.

XII. SUMMARY

FMCGs are frequently purchased low-involvement products that satisfy a basic and fundamental need of the consumer(s). Like the other sectors, the FMCG sector is also subject to diverse business risks. Competitive intensity, irregularity of monsoons, fast changing consumer tastes and preferences as well as the unpredictability in commodity prices especially the petroleum crude, vegetable fats, chemicals and packaging materials particularly affects this sector. Annual Reports of three leading FMCG majors in the country, viz., HUL, NIL and DIL were closely scrutinized and their ERM system was studied. Their risk management strategies were studied and new opportunities that opened vistas for growth were found out.

12.1 A Study of the Three Top Most FMCG Companies Brings about the following Facts

12.1.1 Corporate Risk Assessment and Internal Audit

The companies should have strong systems of Corporate Risk Assessment, Risk Mitigation and Internal Audit.

12.1.2 Debt Equity Ratio

The debt equity ratio should be low and have adequate covers on foreign exchange transactions. The exchange rate risks in the context of imports and exports should be as low as possible or nil.

12.1.3 Control of Input Prices

Sharp increases in input prices (for key raw and packing materials) have often been handled by these corporate through methods vis-à-vis: Use of alternative materials, Value-engineering, Tight control of indirect costs, Forward contracts, Strategic alliances with international and local vendors etc.

12.1.4 Sustainability

These companies now focus on being 'Injury Free' and 'Zero Environment Incident' organizations. Their safety and environmental standards are aligned to international standards of ISO 14001/OHSAS 18001. Their environmental agenda centers around the goals of reducing the environmental impact of their operations.

These FMCG companies, like most others in the industry are eager to pick up indications relating to the changing tastes and preferences of customers. They not only want to work with consumer-centricity but also to mitigate the risk of product obsolescence.

In the world where ‘uncertainty’ has emerged as the only certain event, risk identification and mitigation has been conferred the critical position it richly deserves in the strategic management process of business entities whether big and small. It is the disclosure part which preferably should climb up from the threshold of mere compliance. ERM essentially aims to accomplish organizational objectives and protect stakeholder wealth.

REFERENCES

Book(s)

1. “Principles of Risk and Insurance Management”, Dr. Neelam C. Gulati, Excel Books, New Delhi

Article(s)

1. “Understanding and Articulating Risk Appetite”, KPMG <http://www.kpmg.com/CN/en/IssuesAndInsights/ArticlesPublications/Documents/Risk-appetite-O-200806.pdf> accessed on 5. 8. 2013]
2. “Enterprise risk management in the fast moving consumer goods (FMC) sector in India” ICMAI Journal , October 2013 , Kaberi Bhattacharyya Assistant Professor Netaji Nagar College, Kolkata
3. “A comparative study of growth, challenges and opportunities in FMCG OF Rural Market. “, Kavitha T.C., Inter-science Management Review (IMR) ISSN : 2231-1513, vol.-2 , issue 3, 2012.

Website(s)

1. <http://www.coso.org/-ERM.htm>

Annual Report(s)

1. HUL Annual Reports, Year 2012-13
2. NIL Annual Reports, Year 2012-13
3. DIL Annual Reports, Year 2012-13

TOWARDS THE ACCURACY IN MEDICAL INSTRUMENT

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ABSTRACT

The objective of this paper is to eliminate the human error in the measurement of distance between human jaws during the teeth replacement procedure. A pair of ultrasonic sensor controlled by Arduino is incorporated with this work. A computer is used as display. End product has been examined and tested on patients and we have found that it has the potential to compete with conventional measurement method with the accuracy up to $\pm 0.5\%$ of the total range.

Keywords: *Displacement Measurement, Medical Instrument, Ultrasonic Sensor*

I. INTRODUCTION

Teeth replacement was a common word in countries of Europe and America. In recent years India includes its name in the same. There are many reasons behind teeth replacement. In this process the initial and former step is precise and accurate measurement of the distance between upper and lower jaw. The conventional method followed normally is use of a Vernier caliper for the purpose. It is done manually so that all the data and information depends on the observer or medical instructor present there. Therefore error comes to the picture resulting worse replacement of teeth. In this context we have come up with a new proposal to reduce the human error in the measurement.

An ultrasonic sensor is well known for its accuracy, preciseness and repeatability. Medical ultrasonic transducers (probes) come in a variety of different shapes and sizes for use in making pictures of different parts of the body. The transducer may be passed over the surface of the body or inserted into a body opening such as the rectum, vagina and jaw. Clinicians who perform ultrasound-guided procedures often use a probe positioning system to hold the ultrasonic transducer. Arduino can be used to display the data obtained from the sensor and help to analyze them dynamically.



Figure 1: Proposed Measurement System

In this paper we have proposed a system containing a pair of ultrasonic sensor and Arduino controller to measure the distance between upper and lower jaw with great accuracy and precision so that human error can be eliminated partially or fully. A proposed model with sensors and mechanical structure has shown in Fig.1 during testing on a patient.

II. TECHNICAL APPROACH

A typical vernier scale has shown in Fig.2. It shows sort of manual error during measurement. To eliminate that a new electromechanical model has been proposed containing sensors, controller and computer display.



Figure 2: Typical Vernier Scale

In this work first we have pointed two spot on human face and place our system according to that. Then the patient is instructed to open his or her mouth fully so that we can get the maximum distance between that. Fig.3 shows the initial marking spot during measurement. Once the maximum range is obtained the patient has to repeat the same procedure at least three to four times such that the optimized distance between two jaws can be found. Also this repetition helps to achieve highest accuracy in the measurement. Arduino controller is used to interface between computer and ultrasonic sensor.



Figure 3: Measurement Procedure

III. MACHINE AND MECHANISM

Once the instrument is set with the marked point on patient face and patient open up his or her mouth fully the distance between ultrasonic sensor and reflector will be displayed on the computer. The sensor used in this work has shown in Fig.4.

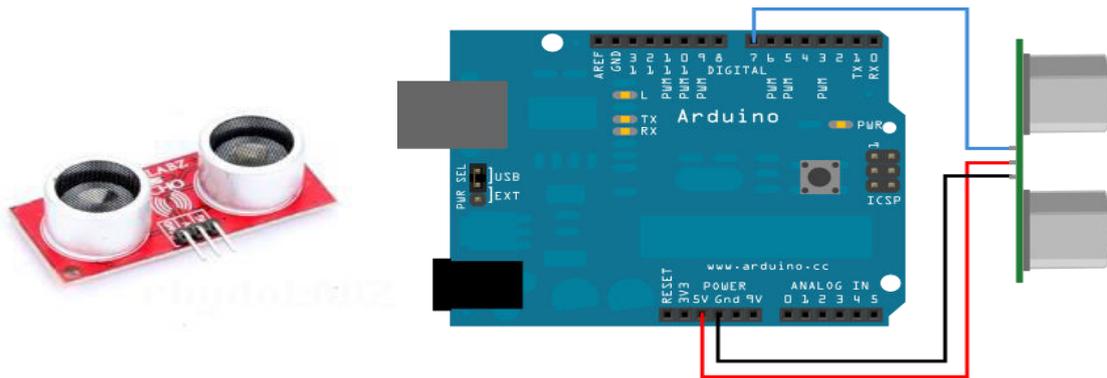


Figure 4: Ultrasonic Sensor and its Schematic Interface with Arduino Controller

A Rhydolabz's "ECHO" Ultrasonic Distance Sensor with ASCII serial O/P is an amazing product that provides very short to long-range detection and ranging. The sensor provides precise, stable non-contact distance measurements from about 2cm to 4 meters with very high accuracy. Its compact size, higher range and easy usability make it a handy sensor for distance measurement and mapping. The board can easily be interfaced to microcontrollers RX pin (USART) . At every 50ms sensor transmits an ultrasonic burst and send out ASCII value of distance that corresponds to the time required for the burst echo to return to the sensor. This sensor is perfect for any number of applications that require you to perform measurements between moving or stationary objects. Naturally, robotics applications are very popular but you'll also find this product to be useful in security systems or as an infrared replacement if so desired. Since it is very stable, the "ECHO" Ultrasonic sensor module can be used for Micro-mouse application instead of IR sensor. Fig.5 shows schematic electronic connection between sensor and controller.

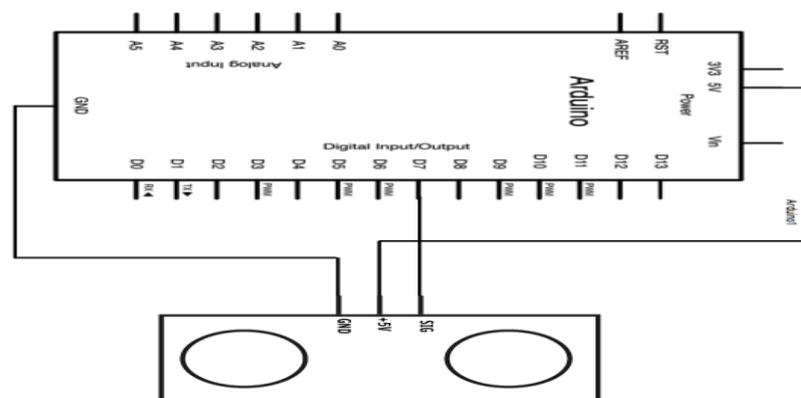


Figure 5: Electronic Connection

IV. RESULT

Distance between two jaws were measured using both the methods; conventional using Vernier scale and proposed system, and Fig. 6 explains the comparison between actual, proposed and conventional data. It is clearly showing that measurement using proposed system is more accurate and precise than that of the conventional measuring system.

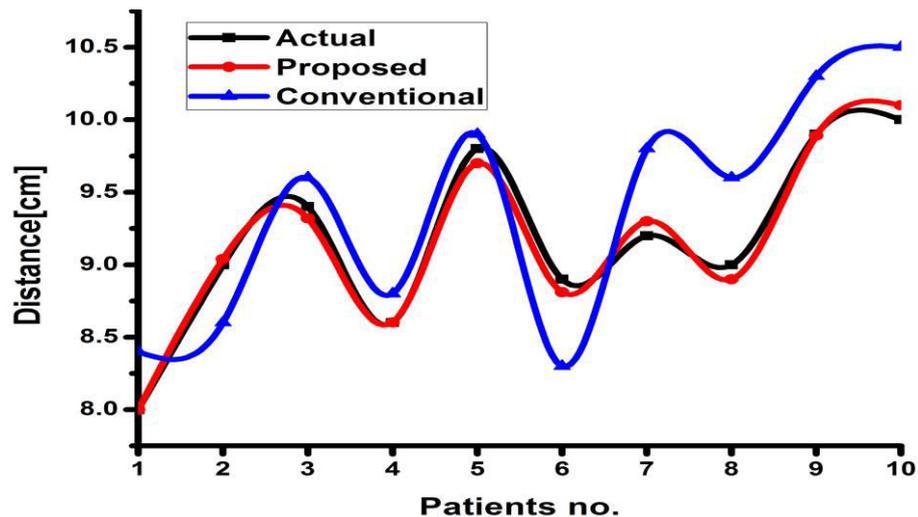


Figure 6: Comparison Among Actual Data, Data from Proposed Model and Data From Conventional Vernier Caliper Method

V. CONCLUSION

We have successfully implemented this work with hardware set up. Proposed system has been tested on number of patient. Inclusion of electronics in the measurement system has shown great improvement in accuracy. Also this suggested method has operated faithfully during dynamic measurement system. Although total system costs a bit more than conventional vernier caliper method, mass production will be effective where human body is concern.

VI. ACKNOWLEDGEMENT

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REFERENCES

- [1] Y. Nagashima and S. Yuta, "Ultrasonic sensing for a mobile robot to recognize an environment — Measuring the normal direction of walls—," Proc. IEEE/RSJ Int. Conf. Intelligent Robots and Systems, Raleigh, NC, U.S.A., Vol. 2, pp. 805–812, July (1992).
- [2] K. W. Jorg and M. Berg, "Sophisticated mobile robot sonar sensing with pseudo-random codes," Robotics Auton. Syst., 25, 241–251 (1998).
- [3] J. Klahold, J. Rautenberg and U. Ruckert, "Continuous sonar sensing for mobile mini-robots," Proc. 2002 IEEE Int. Conf. Robotics and Automation, Washington, DC, U.S.A., Vol. 1, pp. 323–328, May (2002).
- [4] D. Marioli, E. Sardini and A. Taroni, "Ultrasonic distance measurement for linear and angular position control," IEEE Trans. Instrum. Meas., 37, 578–581 (1988).
- [5] D. Marioli, C. Narduzzi, C. Offelli, D. Petri, E. Sardini and A. Taroni, "Digital time-of-flight measurement for ultrasonic sensors," IEEE Trans. Instrum. Meas., 41, 93–97 (1992).
- [6] M. Pollakowski and H. Ermert, "Chirp signal matching and signal power optimization in pulse-echo mode ultrasonic nondestructive testing," IEEE Trans. Ultrason. Ferroelectr. Freq. Control, 41, 655–659 (1994).

- [7] H. Matsuo, T. Yamaguchi and H. Hachiya, "Target detectability using coded acoustic signal in indoor environments," Jpn. J. Appl. Phys., 47, 4325–4328 (2008).
- [8] T. Fukui, M. Segawa, M. Kurosawa, K. Oka and T. Higuchi, "A control system with single-bit digital signal processing," Proc. 4th Int. Conf. Control, Automation Robotics and Vision, Singapore, pp. 1992–1996 Dec., (1996).
- [9] S. R. Norsworthy, R. Schreier and G. C. Temes, Delta-Sigma Data Converters Theory, Design, and Simulation (IEEE Press, Piscataway, N.J., 1997).
- [10] S. Hirata, M. K. Kurosawa and T. Katagiri, "Cross-correlation by single-bit signal processing for ultrasonic distance measurement," IEICE Trans. Fundam., E91-A, 1031–1037 (2008).

AUTOMATED TRANSPORTATION SYSTEM FOR MULTI-FLOOR PACKAGING INDUSTRY

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ABSTRACT

In this paper we consider the limitations of multi-floor packaging industry where the main problem is to transport heavy weight boxes from one floor to another floor accurately and safely for labelling or testing. For this process they require large number of labours. We provided new solution for this problem using automated conveyer system with chain socket mechanism lift, sensors and plc based controller to reduce labour costs, improve safety in high precision delivery so that it will help to boost the efficiency in the transportation of manufactured products in packaging industry.

Keywords: Automation, Lift Mechanism, Programmable Logic Controller (plc)

I. INTRODUCTION

Mainly in packaging industry the problem is to transport heavy weight box packages from one floor to another floor so it requires more labours and times to achieve the goal. Sometimes mishap occurs in the form of physical and mental injury of labours due to heavy weight boxes transportation continuously from one place to another place. Previously solutions are provided to this problem with micro-controller but low precision and constrain of high voltage usage limits its application. A plc has the potential application in industry as it can overcome the above mentioned limitations. In this paper we have come up with a new proposal to fully automate the packaging industry with the help of different sensors, lift with load measuring capability and programmable logic controller. Different industrial aspects were discussed: sensors, actuators, controller and mechanical designs. Fig.1 elucidates actual model of our proposed transportation system.



Figure 1: Actual Model

II. TECHNICAL APPROACH

In fully automated packaging industry requires lift with sensors like load sensor and proximity sensor for measurement of load, and presence and count of boxes respectively. Based on sensors data the lift movement will achieved. In this work we incorporated counter to measure the number of boxes as lift will be actuated only after maximum number of boxes will be reached up to five. Again if sometimes this counter starts malfunctioning another sensor which is load sensor is present to detect the load. If the maximum load is over 1 kg it will automatically starts the lift to move down and red light along with alarm will be set. A chain mechanism with cam follower inside is used for the movement of lift and replacing packages from lift to the exit conveyor respectively.

The sensor used for our FASMPI (Fully Automated System for multi floor Packaging Industry) system includes load sensor, proximity sensors and limit switches. Load sensor mainly use for detection of box weight. Proximity sensors are used for different purpose such as detection of boxes on the lift platform and in conveyor, and for counting number of boxes on platform. Two limit switches has been used to limit the movement so that the lift will stop at predefined position. After analyzing all the data obtained from the above mentioned sensor, a controller which is plc here will take decision whether the lift will start or stop.

A high torque d.c motor is used for the motion of both the conveyor and the lift. To replace conventional microcontroller, a plc is used as a controller to interface sensor and actuator. The number of I/O is mentioned in algorithm depicted in Fig.3

III. ALGORITHM

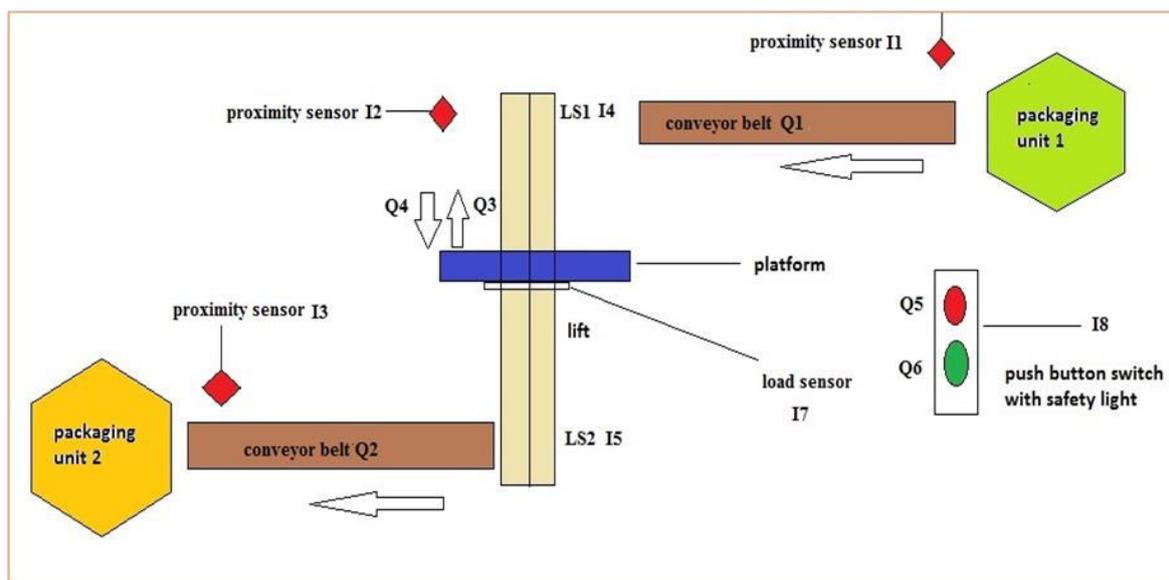


Figure 2: Schematic Diagram

Fig.2 shows the block diagram of proposed model. Respective address used in plc programming has shown in this figure. Work flow illustrated in Fig.3.

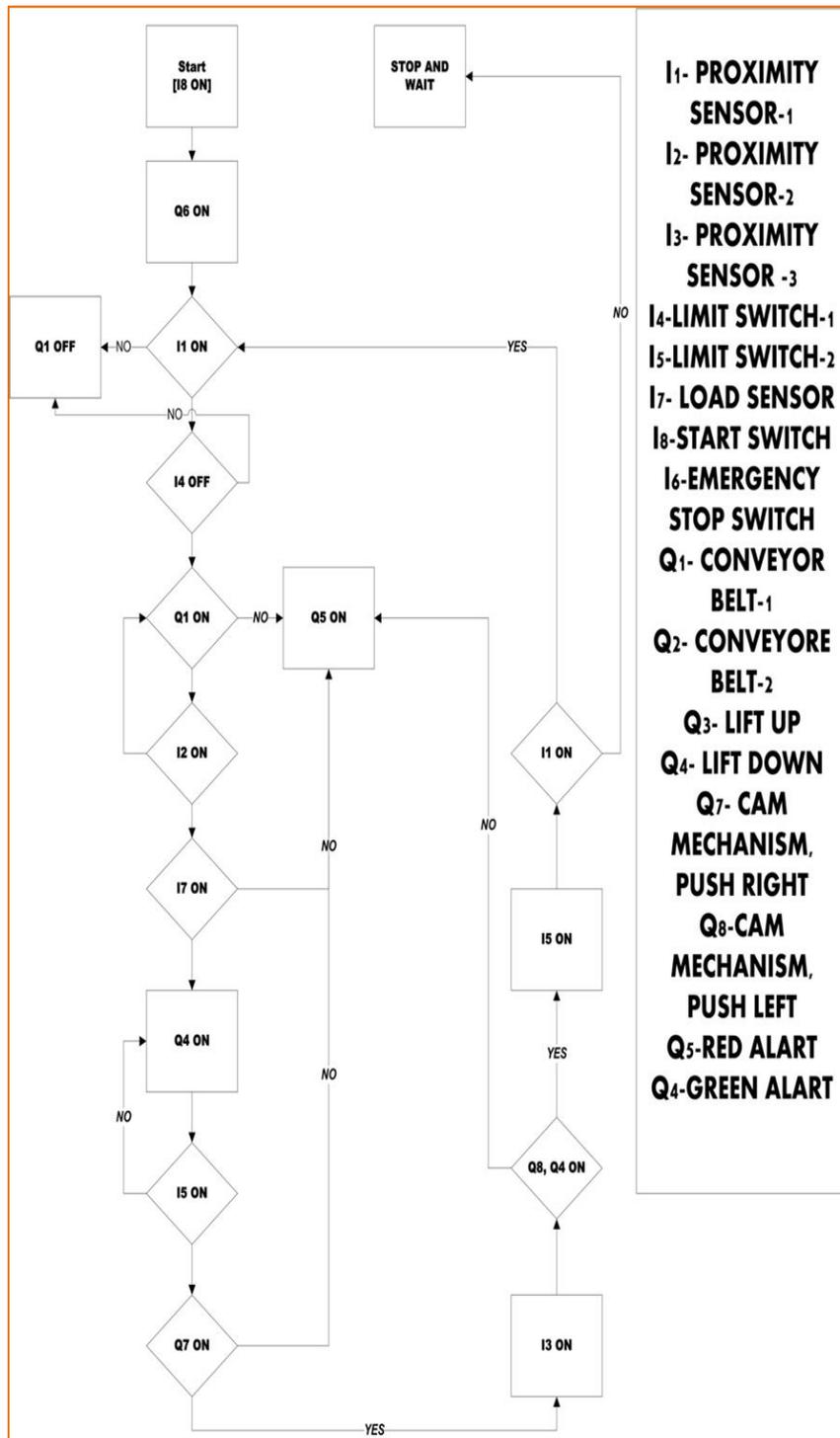


Figure 3: Algorithm

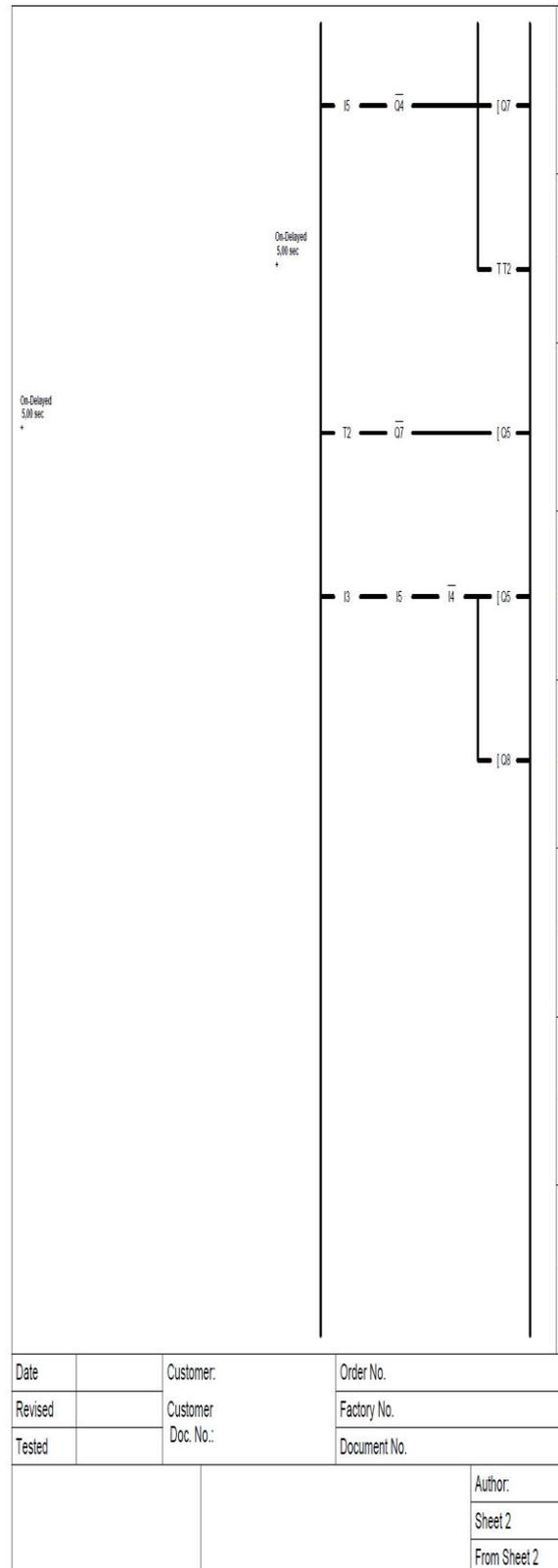
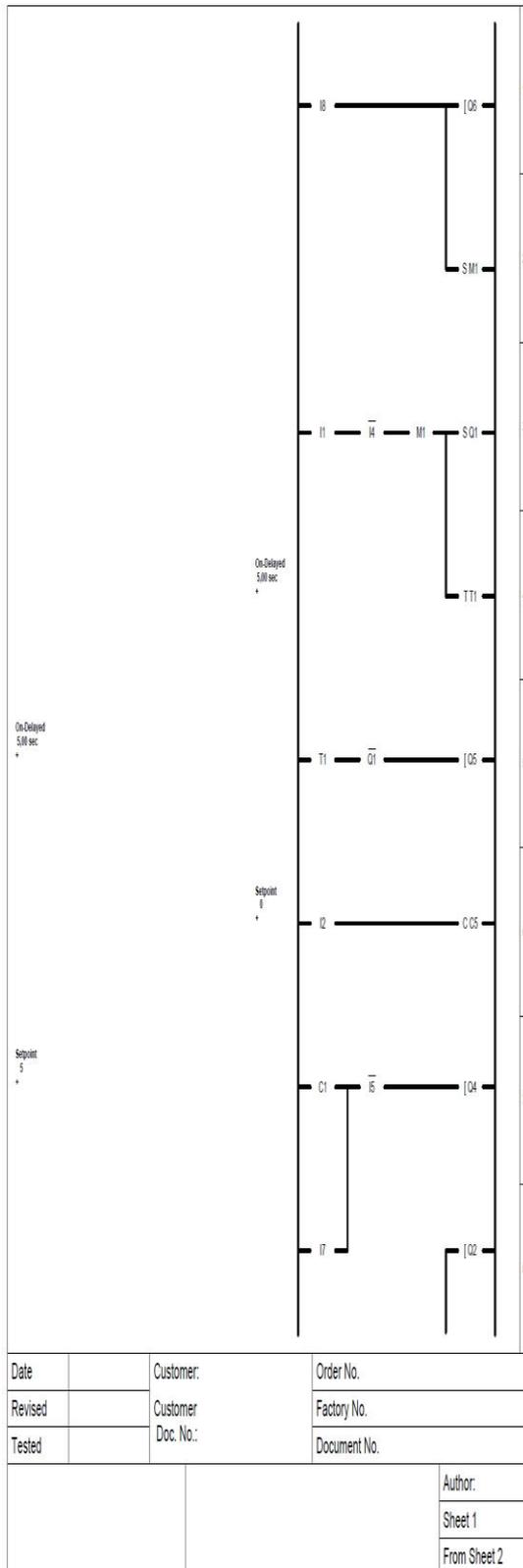


Figure 4: Ladar Logic

III. CONCLUSION

We have successfully run the algorithm with hardware and it works successfully. From this work we can conclude that

- Microcontroller is a low cost special purpose device. It can handle low power application. But for industrial application plc has the potential to compete with other controller including microcontroller.
- Automation is always advantageous than manual work. The design we proposed for heavy load transportation is more efficient and cost effective.
- Proximity sensors are well available in market. Not only that, it has shown better accuracy and repeatability than that of a IR-TSOP based configuration.
- In normal heavy transportation industry, hydraulic mechanisms are used but chain based cam followers are simple and cost effective.

REFERENCES

- [1] A. G. Bachrach, "Autonomous flight in unstructured and unknown indoor environments," Master's thesis, MIT, Cambridge, MA, Sept.2009
- [2] E. S. Kardoss, K. Balian, I. Wahl, "Design of a Semi-Autonomous Park Assist System," Proceedings of The European Control Conference, 2009, pp. 497-516.
- [3] Alan J. Crispin, "Programmable Logic Controllers and their Engineering Applications", 2nd Edition, Reprinted 1997.
- [4] Solomon S, Sensors Handbook. McGraw-Hill, New York, 1999
- [5] "MOEA industry problem-solving group helps develop robot-based multi-floor smart automated delivery system to boost factory utilization and efficiency" published on 2015-04-16 By Industrial Development Bureau, MOEA
- [6] Roger W. Bolz P.E. 3A Industry Applications: Multi floor Automated Delivery
- [7] Nazzal N., Ahmed E. N., "Survey of Research In Modeling Conveyor-Based Automated Material Handling Systems In wafer fabs," In Proceedings of the Winter Simulation Conference, 2007.

EFFECT OF IONIC STRENGTH ON SWELLING OF GELATIN HYDROGELS IN MARGINAL SOLVENTS

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ABSTRACT

Swelling behavior of gelatin hydrogels prepared in different concentration of NaCl suspended in ethanol-water marginal solvent was studied at room temperature (20^oC). The swelling ratio was measured by measuring the change in the mass of the gel to the original gel mass. It was found that the gel containing 0.01M NaCl shows more swelling than the normal gel without salt which infer that the salt concentration gives strength to the gels which swells more than normal gels. The laser light scattering technique was used to estimate the mesh size of swollen gel in marginal solvent and effect of ionic strengths were analyzed. It was also observed that electrostatic interaction helps in swelling (at low concentration of salt) as well as collapsing (at high concentration of salt) of gel network.

Keywords: Gelatin, Hydrogels, Swelling, Dynamic Light Scattering

I. INTRODUCTION

A typical gel is a mixture of a cross-linked polymer network and a solvent having non zero shear modulus [1]. In a gel, the liquid (solvent) prevents the polymer network from collapsing into a compact mass and the network in turn retains the liquid. Gels are of two types based on the formation, (1) physical gels [2-4]: The gels are formed and stabilized in the solvent by physical interaction mostly through hydrogen bonding, van der Waal forces, hydrophobic and ionic interaction for example gelatin, agarose etc, (2) chemical gels [4]: the gels formed by a reaction for example copolymerization, polycondensation, vulcanization etc leading to formation of a branched or a cross-linked network attached by covalent bonds and surrounded by large quantity of solvent. The gel can change its volume by taking in or expelling out the solvent or by some external forces. Such volume phase transitions occurring in both physical and chemical gels [3-4] have been observed in a variety of thermodynamical situations [5]. A small change in the environmental condition of supporting medium like temperature, pH, ionic strength, quality of solvent etc. leads to swelling or de-swelling of gel network. A detailed study of swelling and syneresis of gelatin gel at 5^oC with various concentration of gelatin at acetate buffer at pH 4.7 were done in past [6].

A typical polyelectrolyte gel consists of a charged network of macroscopic size and having an abundance of counterions. The trapped counterions present inside the gel generate positive internal osmotic pressure in order to establish Donnan equilibrium with the surrounding solvent. Counterions are free in the solvent whilst they are trapped in the equilibrium gel to ensure macroscopic electrical neutrality. The osmotic pressure of these trapped counterions with no counterpart in solution can be identified to be the main reason for giving rise to swelling.

Effect of monovalent and divalent salt on osmotic properties of DNA gels was studied by Horkay and Bassar[7], which revealed that gels can maintain higher ion and polymer concentration without causing macroscopic phase transitions.

We have investigated previously the effect of swelling in marginal solvent at different pH. In the present work, we investigate the swelling and de-swelling kinetics of a gelatin hydrogel prepared in different ionic strength of NaCl suspended in water-ethanol binary solvent at slightly above than pI, since the degree of ionization is not known with the pH. Volume changes were monitored as function of time until equilibrium was observed, and mesh size was also estimated for swollen/shrunken gel using laser light scattering technique. The effect of swelling is presented in terms of scattered intensity correlation function, how the correlation function changes with swelling/de-swelling?

II. MATERIALS AND METHODS

Gelatin (300 bloom, type A, nominal pI \approx 4.9) bought from Sigma-Aldrich, USA, was used to prepare the samples. The molecular weight of gelatin was (100 \pm 10) kD. The solutions were prepared by dissolving gelatin powder (5% w/v) in pre-heated (at 50 $^{\circ}$ C) water with different concentration of NaCl which was further stirred for 1 hr to produce a homogeneous solution. A small quantity of Sodium Azide (NaN₃) was added to the samples to prevent bacterial contamination. The solution pH was titrated to 5.2 for the good solubility of the gelatin. These samples were stored at room temperature (20 $^{\circ}$ C) overnight, allowing these to cool slowly through Newtonian cooling and which form gels. The gel samples appeared transparent to the eye and did not contain air bubbles, sometime in the course of preparation of solution of gelatin if the speed of stirrer is high then it form air bubble inside the gel after cooling the solution. A series of 6 marginal solvents of water-ethanol binary mixture (0, 10, 30, 45, 60, and 100 % of ethanol) was prepared. Six cubes of gel were cut each measuring 1.0 cm X 1.0 cm X 1.0 cm approximately. These were weighed on a Mettler micro-balance and released into the beakers containing the marginal solvents. Thus, we had one gel-cube in each separate solvent beaker. The beakers were sealed and stored at 20 $^{\circ}$ C. The gel-cubes were taken out carefully at repeated intervals; the minute amount of solvent on the gel surface was carefully wiped with tissue paper without touching the surface, and weighed again to ascertain gain or loss in weight. These were returned to the solvents immediately following weighing. This procedure was continued till swelling equilibrium was noticed as evidenced from observation of invariance of weight of gel-cubes with time. Typically, a gel-cube was weighed 18 times during this period. The reported degree of swelling is defined as $w = (w_2 - w_1)/w_1$, where w_2 and w_1 are the swollen (at time $t = t > 0$) and dry weight (at time $t = 0$) of the gel sample. The value of degree of swelling less than one it means there is a de-swelling and more than one means that there is a swelling i.e. solvent were entered into or came out of the gels. Dynamic light scattering (DLS) experiments were performed (scattering angle=90 $^{\circ}$, laser wavelength=632.8 nm) on a 256 channel Photocor-FC (Photocor Inc., USA) that was operated in the multi-tau mode (logarithmically spaced channels). Small cubical shape gels were placed in different marginal solvent into the quartz cell and intensity correlation was measured. The data was analyzed both in the CONTIN regularization and discrete distribution modes (multi-exponential). The CONTIN software generates the average relaxation time of the intensity correlation function, which is solely related to Brownian dynamics of the diffusing networks inside the gels. This yielded the apparent translational diffusion coefficient values. Correspondingly, the apparent mesh size of the network, ζ , at room temperature (20 $^{\circ}$ C) was determined from the knowledge of

translational diffusion coefficient, D_T which was obtained by fitting the intensity correlation function. These values were used in Stoke-Einstein equation, $D = k_B T / f$ with the translational friction coefficient, $f = 6\pi\eta_0\zeta$ where k_B is Boltzmann constant, and η_0 is solvent viscosity.

III. RESULTS AND DISCUSSION

The nominal pI of gelatin is 4.9. Since the solubility of gelatin at this pH is very low we conducted swelling experiments slightly above pI (at pH= 5.2). At this pH there is ought to be an exact balance of positive and negatively charged sites on gelatin network. Typically elastic free energy and volume mixing energy is involved in the deformation of gel in a solvent. This would also imply that the co-ion and counter-ion concentration inside the gel is identical, which will be higher than the same in the surrounding solvent. Thus with respect to each of these two types of ions, there would be an osmotic pressure arising from Donnan effect. All the swelling of gel in marginal solvent data were presented in Figure 1 to Figure 2 corresponding to different concentration of the salt. Swelling and de-swelling behavior in different ethanol-water mixture for different ionic strength gel are summarized in table 1.

Interestingly near to the concentration of 45% ethanol concentration there was minimal volume change of the gel. Maximum swelling was observed in the solvent containing 0% ethanol. Swelling behavior was observed for spherical shaped gel where the swelling ratio increases/decreases exponentially [8], $r = r_0 (1 - \exp(-t / \tau))$, where ‘ τ ’ is characteristic time, and r_0 is the initial size of the gel. A similar behavior was observed for all cases of swelling, and also very similar behavior for de-swelling gel with different characteristic time constant.

De-swelling of gels was observed at above 45% ethanol concentration in our studies. For these gels the volumes shrunk by almost 50%. In the past, volume collapse in polyelectrolyte gels has been attributed to ion-pair formation with their aggregation to multiplets. In contrast to a polar medium where counterions are mobile inside the gel volume in solvents of low polarity, ion-pairing is facilitated between complementary ions by the low dielectric constant of the partially polar medium due to dipole-dipole interactions.

Table 1. Swelling /Deswelling of Gelatin Gel of Different Salt Concentration with Different Marginal Solvent

Ethanol NaCl → ↓	0%	10%	30%	45%	60%	100%
0M	S	S	S	NC	DS	DS
0.01M	S	S	S	NC	DS	DS
0.1M	S	S	S	NC	DS	DS
1.0M	S	S	DS	DS	DS	DS

S= swelling, NC= No Change, DS= Deswelling.

Table 2 Mesh Size of Gelatin Gel Measured by Dynamic Light Scattering in Marginal Solvent

NaCl conc.	0%Ethanol Mesh size(nm)	100%Ethanol Mesh size(nm)
0M	187, 212,360	67,67,63

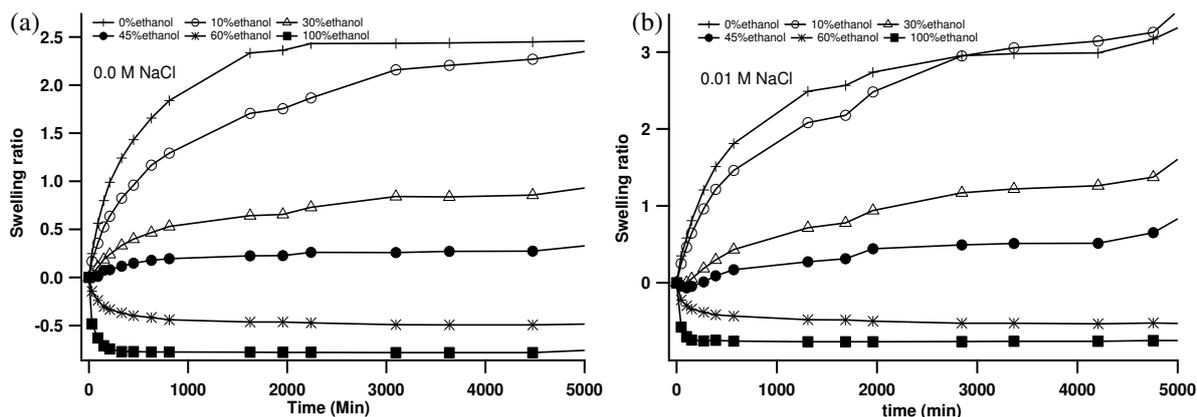


Figure 1 Swelling Ratio Versus Time (in min) for (a) 0.0 M NaCl and (b) 0.01 M NaCl

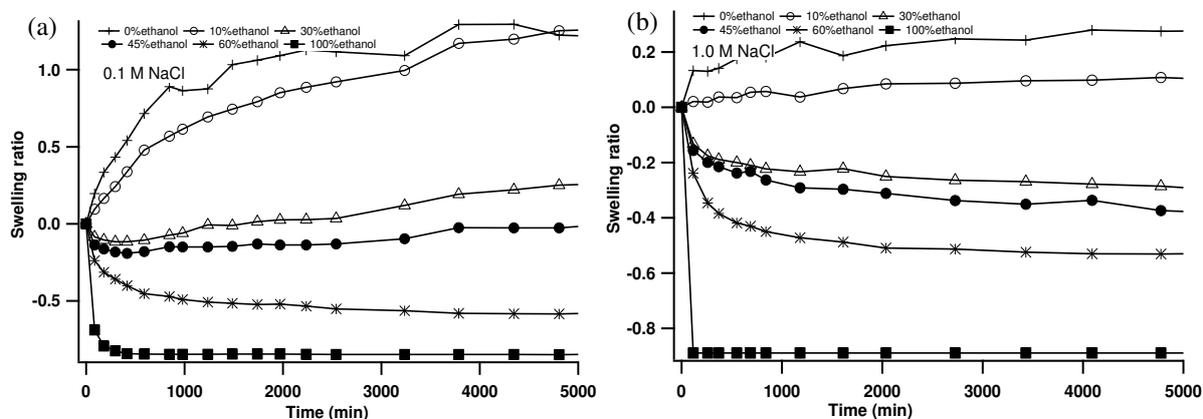


Figure 2 Swelling Ratio Versus Time (in min) for (a) 0.1 M NaCl and (b) 1.0 M NaCl

It is very clear from the graph (Figure 2b) for 1M NaCl solution that the de-swelling takes place after 30% ethanol concentration. It means that NaCl present in the solution screen the total charge present on the polymer chain. Thus the osmotic pressure due to the ionic part increases as the concentration of the ethanol increases from 30% onwards. It also means that the hydrophobicity due to the ethanol increases after this concentration. The dielectric constant of the ethanol-water solvent is less than the pure water solvent; this may also be the cause for the de-swelling of the gels from this concentration of salt as well as ethanol.

In our experiments, volume reduction in gel samples was observed for ethanol concentrations > 45% (v/v). The dielectric constant of water is 78.5 while that for ethanol is 24.3. Swelling behaviors was clearly observed in solvents containing ethanol concentration up to $\approx 45\%$ (v) that refers to solvent dielectric constant ≈ 60 . When the dielectric constant value of the solvents was less than 60, we started observing gel collapse regardless of the salt concentration. It can be argued that the critical degree of ionization of gel network is reached at ethanol concentration $\approx 45\%$. Thus, this ethanol concentration defines the boundary between swelling and collapse behavior of physical gels [9]. This type of volume phase transition [10-13] observed by our previous work in the course of simple coacervation.

Swelling/Deswelling of gel was quantitatively verified with the Dynamic Light Scattering experiment by measuring the network size during swelling/de-swelling time and in different marginal solvent. As the gel swells/de-swells the size of the network increases/decreases respectively. It is very difficult to measure the scattering from the gel in course of swelling or de-swelling because the dynamics of bound solvent so the system is not in ergodic equilibrium. So an average network size was estimated from correlation function at

different time. The network sizes of the gel were estimated only for pure water (increasing size) and pure ethanol solvent (decreasing size). The pure ethanol is poor solvent for the all prepared gel in different salt approaches an equilibrium collapsed network size within an hour and no more change in the network size was observed. The intensity correlation function from gel in the pure water solvent is very much fluctuating compared to the pure ethanol solvent which describes the collapse of the network in poor solvent (see Figure 3 to Figure 4), also it was observed fluctuating correlation function for smaller salt concentration compared to higher salt content gels.

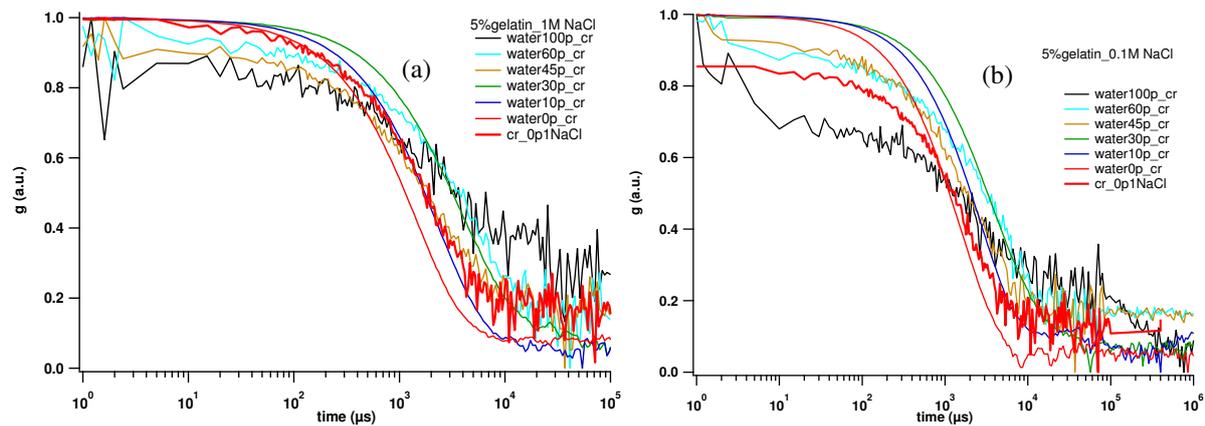


Figure 3. Intensity Correlation Functions from Gel Containing (a) 1 M NaCl and (b) 0.1 M NaCl.

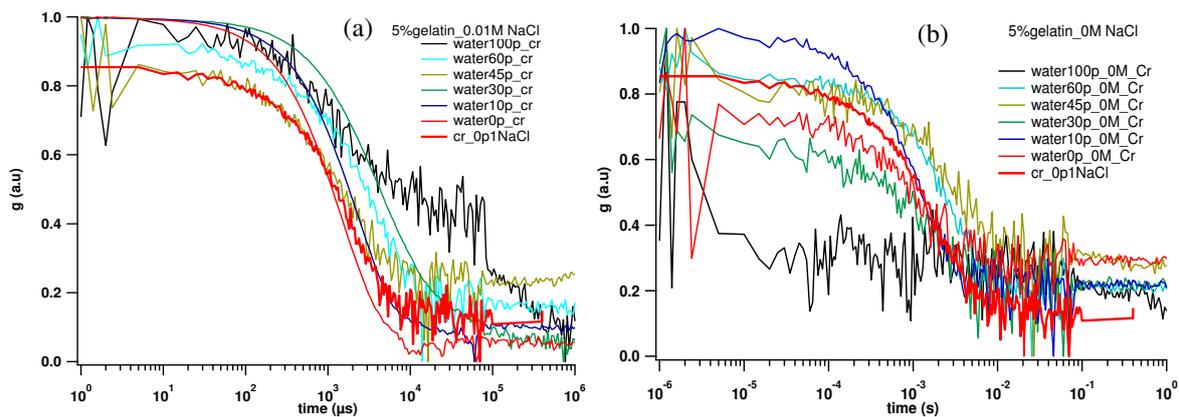


Figure 4 Intensity Correlation Functions from Gel Containing (a) 0.01 M NaCl and (b) 0.0 M NaCl

IV. CONCLUSION

Swelling and de-swelling equilibrium in gelatin hydrogels of different sodium chloride concentrations suspended in ethanol-water binary solvent was studied as function of varying ethanol concentration, which was a marginal solvent for gelatin. It was found that there was a normal swelling in gels in which there were no salt. But in case of those gels which were prepared in salt solution shows very interesting results. As the concentration of salt was increased the swelling gets affected and it was found that for 0.01M NaCl gel which shows more swelling than the normal which infer that the salt concentration (0.01M NaCl) gives strength to the gels which swells more than normal gels in the same period of time. There may be a strong interaction between the gel biopolymer network and the salt, which tighten the network and last for longer time. Again we found that after the addition of more salt the trend is normal and there was regular collapse of gel network in case of 0.1M

and 1M NaCl concentration in the same time domain. Gels prepared at normal pH exhibited swelling when ethanol concentration was less than $\approx 40\%$ (v/v). For ethanol concentrations greater than 40% (v/v), de-swelling or gel collapse was noticed in all gel samples. This behavior could be qualitatively understood through the formalism of ion-pair formation, and the consequent dipole-dipole interactions between the charged network and, counter and co-ions. Swelling/de-swelling of gel was quantitatively verified with the Dynamic Light Scattering experiment by measuring the network size with time and with different marginal solvent.

REFERENCES

- [1] Flory PJ, and Rehner J Jr., Statistical Mechanics of Cross-Linked Polymer Networks II. Swelling, Journal of Chemical Physics, 11, 521, 1943.
- [2] Bohidar HB, Dubin P, and Osada Y. Polymer Gels: Fundamentals and Applications, Ed.; ACS vol. 833, Washington DC, 2002.
- [3] Flory PJ. Principles of Polymer Chemistry; Cornell University Press: Ithaca, New York, 1953.
- [4] Cohen M. Physical Properties of Polymeric Gels, Ed.; Wiley: New York, 1996.
- [5] teNijenhuis K., Thermoreversible Networks- Viscoelastic Properties and Structure of Gels, Adv. Polymer Sci., 1, 130, 1997.
- [6] Hochberg A., Tanaka T. and Nicoli D., Spionodal Line and Critical Point of an Acrylamide Gel, Phys. Rev. Letts., 43, 217, 1979.
- [7] Horkay F., and Bassar P., Osmotic Observations on Chemically Cross-Linked DNA Gels in Physiological Salt Solutions, Biomacromolecules, 5, 232, 2004.
- [8] Tanaka T., Sun S., Hirokawa Y., Katayama S., Kucera J., Hirose Y., and Amiya T., Mechanical instability of gels at the phase transition, Nature, 325, 796, 1987.
- [9] Peters A., and Candau S.J., Kinetics of swelling of spherical and cylindrical gels, Macromolecules, 21, 2278, 1988.
- [10] Geissler E., Bohidar H B., and Hecht AM., Collective Diffusion in Semidilute Gels at the θ Temperature, Macromolecules, 18, 949, 1985.
- [11] Gupta A., and Bohidar HB., Kinetics of phase separation in system exhibiting simple coacervation, Phys. Rev. E, 72, 011507, 2005.
- [12] Dhara D., and Chatterji PR. Effect of Hydrotropes on the Volume Phase Transition in Poly(*N*-isopropylacrylamide) Hydrogel, Langmuir, 15, 930, 1999.
- [13] Boral S., Gupta A N., Bohidar H B., Swelling and de-swelling kinetics of gelatin hydrogels in ethanol-water marginal solvent., International Journal of Biological Macromolecules, 39, 240, 2006.

EFFICIENT CLASSIFIER FOR PREDICTING HEART DISEASE THROUGH FEATURE RELEVANCE ANALYSIS

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ABSTRACT

Feature relevance analysis plays a vital role in clinical data mining as it has a high impact in classifying the disease. In general for detecting a disease number of tests should be required from the patient. But through data mining technique the number of test required for analyzing the disease is greatly reduced. In this paper Heart Disease Dataset is taken from UCI Machine Learning Repository for this research work. Initially preprocessing and feature relevance analysis is done before classification in order to obtain the quality results. Then various classifiers are applied on this dataset. Finally, Cross validation is done on all the classifier for the test data to evolve the best classifier for predicting the hard disease. Here, Random tree classifier given the best classification results.

Keywords: *FSF Classifier, Feature Relevance Analysis, Heart Dataset, Rand Tree*

I. INTRODUCTION

Mining is the process of extracting hidden knowledge from large volumes of raw data. The knowledge must be new, not obvious, and one must be able to use it. Data mining has been defined as “the nontrivial extraction of previously unknown, implicit and potentially useful information from data. It is “the science of extracting useful information from large databases”. It is one of the tasks in the process of knowledge discovery from the database. [1]

Data Mining is used to discover knowledge out of data and presenting it in a form that is easily understand to humans. It is a process to examine large amounts of data routinely collected. Data mining is most useful in an exploratory analysis because of nontrivial information in large volumes of data. It is a cooperative effort of humans and computers.

Best results are achieved by balancing the knowledge of human experts in describing problems and goals with the search capabilities of computers. There are two primary goals of data mining tend to be prediction and description. Prediction involves some variables or fields in the data set to predict unknown or future values of other variables of interest. On the other hand Description focuses on finding patterns describing the data that can be interpreted by humans. The Disease Prediction plays an important role in data mining. There are different types of diseases predicted in data mining namely Hepatitis, Lung Cancer, Liver disorder, Breast cancer, Thyroid disease, Diabetes etc... This paper analyzes the Heart disease, Diabetes and Breast cancer disease predictions.

II. ARCHITECTURAL DESIGN

The architectural design of the proposed system is given in Fig 1 and each block is explained in the following sections.

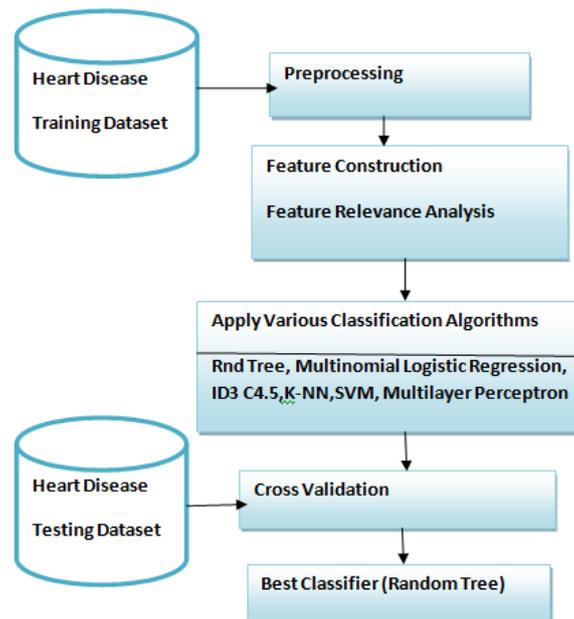


Fig. 1 Architecture Design of the Proposed System

2.1 Input Dataset

The Heart Disease Dataset is taken from UCI Machine Learning repository. It consists of 14 attributes (13-input attributes, 1-target attribute) and 303 instances. The dataset field specifies the presence of heart disease in the patient. The description of the attributes of this Heart disease dataset is given in Table 1.

Table. 1 Attribute of Heart Disease Dataset

Attribute No	Attributes
1	age
2	sex
3	chest pain type (4 values)
4	resting blood pressure
5	serum cholestorol in mg/dl
6	fasting blood sugar > 120 mg/dl
7	resting electrocardiographic results (values 0,1,2)
8	maximum heart rate achieved
9	exercise induced angina
10	oldpeak = ST depression induced by exercise relative to rest
11	the slope of the peak exercise ST segment
12	number of major vessels (0-3) colored by flourosopy
13	thal: 3 = normal; 6 = fixed defect; 7 = reversable defect

2.2 Data Preprocessing

Nowadays, most of the data in the real world are incomplete containing aggregate and missing values, noisy data containing errors, inconsistent data containing discrepancies in codes and names. As the quality decision depends on quality mining which is based on quality data, pre-processing becomes a very important tasks in any mining related activity. Major tasks in data pre-processing are data cleaning, data integration, data transformation and data reduction. In this dataset data cleaning is done to fill up the missing values with its corresponding mean values.

2.3 Feature Relevant Analysis

Feature relevance analysis is an important area in which pattern recognition, machine learning and statistics are widely done in data mining communities. Here in Feature relevance analysis feature construction and feature selection is done. The main objective of feature selection is to choose a subset of input variables by eliminating features, which are irrelevant or of no predictive information. Feature selection techniques provide three main benefits like improved model interpretability, shorter training times, and enhanced generalisation by reducing over fitting with respect to predictive models. Feature selection is also useful as part of the data analysis process, as it shows which features are important for prediction, and how these features are related.

2.4 Feature Construction

Feature Construction attempts to discover relations between the existing features and creates new features that reflect those relations. In feature construction good high level features are concentrated for classification.

2.5 Feature Selection Alorithms

2.5.1 Fisher Filtering

Fisher filtering is a supervised feature selection algorithm [13] which processes the selection independently from the learning algorithm. It follows univariate Fisher's ANOVA ranking which ranks the inputs attributes according to their relevance without considering the redundancy aspects of input attributes.

2.5.2 Runs Filtering

Runs filtering [13] are a non parametric test for predictive attribute evaluation. It is an univariate attribute ranking from runs test. It is a supervised feature selection algorithms based upon a filtering approach i.e. processes the selection independently from the learning algorithm. This component ranks the inputs attributes according to their relevance without considering redundancy aspect. A cutting rule enables to select a subset of these attributes.

2.6 ReliefF

ReliefF algorithm [13] detects conditional dependencies between attributes and provides a unified view on the attribute estimation in regression and classification. It is not limited to two class problems, is more robust and can deal with incomplete and noisy data.

2.7 Step Disc

STEPDISC (Stepwise Discriminant Analysis) [13] procedure performs a stepwise discriminant analysis to select a subset of the quantitative variables for use in discriminating among the classes. The set of variables that make up each class is assumed to be multivariate normal with a common covariance matrix. The STEPDISC procedure can use forward selection, backward elimination, or stepwise selection.

2.8 Classification Algorithms

2.8.1 Rnd Tree

A Random forest tree [11] consists of a collection or ensemble of simple tree predictors, each capable of producing a response when presented with a set of predictor values. For classification problems, this response takes the form of a class membership, which associates, or classifies, a set of independent predictor values with one of the categories present in the dependent variable. For regression problems, the tree response is estimated for the dependent variable given by the predictors.

2.9 Multinomial Logistic Regression

In statistics, multinomial logistic regression is a classification method that generalizes logistic regression to multiclass problems, i.e. with more than two possible discrete outcomes. That is, it is a model that is used to predict the probabilities of the different possible outcomes of a categorically distributed dependent variable, given a set of independent variables.

2.10 ID3

In ID3 decision tree, each node corresponds to splitting attribute. It uses information gain to determine the splitting attribute. The attribute with the highest information gain is taken as the splitting attribute. Information gain is the difference between the amount of information needed to make a correct prediction before and after splitting. Information gain can also be defined as the different between the entropy of the original segment and the accumulated entropies of the resulting split segments. Entropy is the measure of disorder found in the data. ID3 can handle high-cardinality predictor variables. A highcardinality predictor is a variable which has different possible values thus having different possible ways of performing a split.

2.11 C4.5

C4.5 is an classification algorithm that is used to generate a decision tree. C4.5 is an extension of earlier ID3 algorithm. The decision trees generated by C4.5 can be used for classification, and for this reason, C4.5 is often referred to as a statistical classifier.

2.12 K-NN

The k-nearest neighbor algorithm (k-NN) [17] is a method for classifying objects based on closest training examples in an n-dimensional pattern space. When given an unknown tuple the classifier searches the pattern space for the k training tuples that are closest to the unknown tuple. These k training tuple are the k nearest neighbor of the unknown tuple.

2.13 SVM

In machine learning, support vector machines are supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. Given a set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other, making it a non-probabilistic binary linear classifier.

2.14 Multilayer Perceptron

It is the most popular network architecture [12] in today world. The units each perform a biased weighted sum of their inputs and pass this activation level through a transfer function to produce their output. The units are arranged in a layered feed forward topology. The network has a simple input-output model, with the weights and thresholds. Such networks can model functions of almost arbitrary complexity, with the number of layers, and the number of units in each layer, determining the function complexity. The important issues in Multilayer Perceptron are the design specification of the number of hidden layers and the number of units in these layers.

III. EXPERIMENTAL RESULTS AND PERFORMANCE EVALUATION

The Heart disease dataset is downloaded from the UCI Machine Learning Repository, the input and target attributes contains only continuous attributes. In order to apply filtering algorithms the entire target attributes have to be transformed either into discrete attributes. Then the filtering algorithms such as ReliefF, Fisher Filtering, Runs Filtering, Stepwise Discriminant Analysis are applied to the feature constructed dataset and the results are given in Table II. Then classification algorithms such as Rnd Tree, Multinomial Logistic Regression, ID3, C4.5, K-NN, SVM, Multilayer Perceptron are applied to each of the above filtering algorithms and the results are given in Table III.

Table. 2 Feature Selection

S.No	Feature selection algorithm	No of attributes Before Filtering	No of attributes After Filtering	Attribute No After Filtering
1	ReliefF	13	6	2,3,7, 9,12,13
2	Fisher Filtering	13	9	1,2,3,8,9,10, 11,12,13
3	Runs Filtering	13	4	3,9,12,13
4	Stepwise Discriminant Analysis	13	8	2,3,7,8,9, 10,12,13

Rnd Tree algorithm produces 100% accurate Results without applying any future relevance analysis Fisher filtering produces 100% accurate results for Rnd–tree algorithms; above 85% accuracy for Fisher filtering and Multinomial Logistic Regression. Fisher filtering produces 85% accuracy for C4.5 algorithm; above 85% for multilayer perceptron filtering and above 85% accuracy for K-NN algorithm and above 85% for SVM. Stepwise discriminant analysis provides above 95% for Rnd –tree algorithm and above 90% accuracy for C4.5 and K-NN classifiers and above 85% for multilayer perceptron classifier. From the results, the Rnd tree classification is considered as a best classifier, as it produced 100% accuracy through all the six classifiers.

Table. 4 Error Rate of Heart disease Dataset Classification

Classification Algorithm	Error Rate Before Filtering	Error Rate After Filtering			
		ReliefF	Fisher Filtering	Runs Filtering	StepDisk
Rnd Tree	0.0000	0.1111	0.0037	0.1296	0.01111
Multinomial Logistic Regression	0.1444	0.1481	0.1407	0.1407	0.137
ID3	0.237	0.237	0.237	0.237	0.237

C4.5	0.0111	0.1333	0.1148	0.1333	0.1185
KNN	0.1333	0.1556	0.1148	0.137	0.1481
SVM	0.1481	0.1519	0.1444	0.1556	0.137
Multi Layer	0.1333	0.137	0.1222	0.1481	0.137

3.1 Error Rate

Error rate of a classifier was defined as the percentage of the dataset incorrectly classified by the method. It is the probability of misclassification of a classifier

$$\text{Error rate} = \frac{\text{No.of incorrectly classified samples}}{\text{Total no of Sample in the class}}$$

3.2 Accuracy

Accuracy of a classifier was defined as the percentage of the dataset correctly classified by the method. The accuracy of all the classifiers used for classifying this TP53 germline dataset are represented graphically in Figure2

$$\text{Accuracy} = \frac{\text{No of correctly Classified Samples}}{\text{Total no of Sample in the class}}$$

3.3 Recall

Recall of the classifier was defined as the percentage of errors correctly predicted out of all the errors that actually occurred. The recall of the best classifier Rnd Tree is given in Figure 3.

$$\text{Recall} = \frac{\text{True Positive}}{\text{True positive} + \text{False Negative}}$$

3.4 Precision

Precision of the classifier was defined as the percentage of the actual errors among all the encounters that were classified as errors.

$$\text{Precision} = \frac{\text{True Positive}}{\text{True positive} + \text{False Positive}}$$

The terms positive and negative refer to the classifier's prediction, and the terms true and false refer to classifier's expectation.

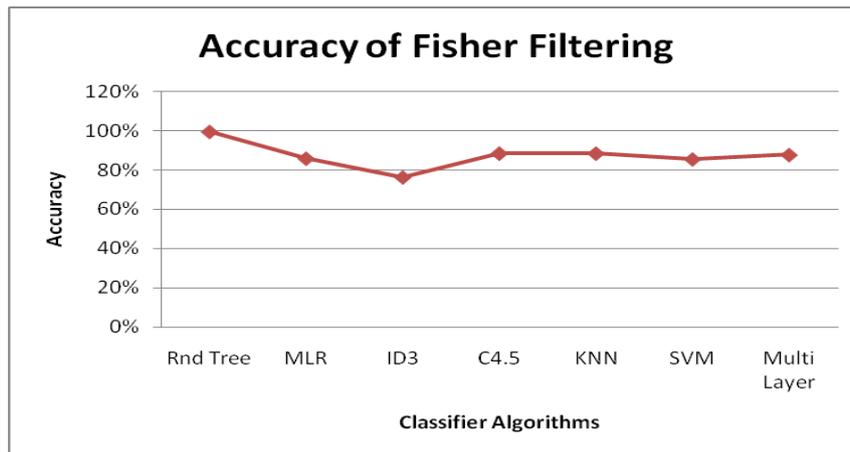


Fig. 2 Accuracy of the Fisher Filtering

IV. CONCLUSION

This work finds the best classifier for predicting the Heart dataset through feature relevance analysis. The evolved classifier has produced 100% accuracy for the Random forest tree classifier using Fisher Filter selection algorithm and it also accurately classified the test dataset.

REFERENCES

- [1]. Han, J., Kamber, M.: "Data Mining Concepts and Techniques", Morgan Kaufmann Publishers, 2006.
- [2] "Data mining: Introductory and Advanced Topics" Margaret H. Dunham
- [3]. Jyoti Soni, Ujma Ansari, Dipesh Sharma, Sunita Soni "Predictive Data Mining for Medical Diagnosis: An Overview of Heart Disease Prediction" IJCSE Vol. 3 No. 6 June 2011.
- [4]. Carloz Ordonez, "Association Rule Discovery with Train and Test approach for heart disease prediction", IEEE Transactions on Information Technology in Biomedicine, Volume 10, No. 2, April 2006, pp 334-343.
- [5] M. ANBARASI, E. ANUPRIYA, N.CH.S.N.IYENGAR, "Enhanced Prediction of Heart Disease with Feature Subset Selection using Genetic Algorithm", International Journal of Engineering Science and Technology Vol. 2(10), 2010, 5370- 5376.
- [6] G. Parthiban, A. Rajesh, S.K.Srivatsa "Diagnosis of Heart Disease for Diabetic Patients using Naive Bayes Method" .
- [7] Bellaachia Abdelghani and Erhan Guven, "Predicting Breast Cancer Survivability using Data Mining Techniques,"Ninth Workshop on Mining Scientific and Engineering Datasets in conjunction with the Sixth SIAM International Conference on Data Mining," 2006.
- [8] Lundin M., Lundin J., BurkeB.H.,Toikkanen S., Pylkkänen L. and Joensuu H. , "Artificial Neural Networks Applied to Survival Prediction in Breast Cancer", Oncology International Journal for Cancer Resaerch and Treatment, vol. 57, 1999.
- [9] Delen Dursun , Walker Glenn and Kadam Amit , "Predicting breast cancer survivability: a comparison of three data mining methods," Artificial Intelligence in Medicine ,vol. 34, pp. 113-127 , June 2005.
- [10] Ruben D. Canlas Jr.,"data mining in healthcare: current applications and issues", August 2009.
- [11] R. Geetha Ramani, G. Sivagami, Parkinson Disease Classification using Data Mining Algorithms, International Journal of Computer Applications (0975 – 8887) Volume 32– No.9, October 2011.

- [12] Shomona Gracia Jacob, R.Geetha Ramani, Discovery of Knowledge Patterns in Clinical Data through Data Mining Algorithms: Multiclass Categorization of Breast Tissue Data, International Journal of Computer Applications (0975 – 8887) Volume 32– No.7, October 2011.
- [13] S. Poonkuzhali, R. Geetha Ramani, R. Kishore Kumar, Efficient Classifier for TP53 Mutants using Feature Relevance Analysis, in International Multiconference of Engineers and computer scientists, Vol 1, 2012.
- [14] Tanagra-Data Mining tutorials <http://data-mining-tutorials.blogspot.com>.

FUZZY RELATION BASED MINIMAL COVER APPROACH FOR AVOIDING REDUNDANT OR DUPLICATE FUZZY FUNCTIONAL DEPENDENCY

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ABSTRACT

Fuzzy data model based on the mathematical framework of fuzzy set theory to process imprecise or uncertain information. While designing such a fuzzy relational database model that does not suffer from data redundancy and anomalies, the current author have introduced dependency based on minimal cover algorithm to ignore the redundant fuzzy dependency and get back minimum numbers of fuzzy functional dependency from the large number of fuzzy functional dependency. This fuzzy functional dependency based on minimal cover algorithm, will help to normalizing the fuzzy unnormalized relation which will try to focus on next paper.

Keywords: FS, FFD, FCAS, DBMC

I. INTRODUCTION

One of the main objectives of any good database design is to decrease data redundancy and provide data consistency. Data redundancies as well as insertion, deletion and updation of anomalies have been of great concern in the design theory of a relational database. But in incomplete or imprecise relation should need some extra tool for avoiding redundant functional dependency and minimize the functional set for healthy maintaining the non discrete relational based data for its consistency. The concept of fuzzy functional dependency based on the idea of α -equality of tuples [1, 2]. The present paper is devoted to minimal cover algorithm based on dependency so that fuzzy relation should free from data redundancies and different kinds of anomalies. Incomplete fuzzy relation concept came from precise relational database with shared data introduced by Codd [3] in 1970.

II. BASIC DEFINITIONS

In this section, we first review the basic definitions of fuzzy set, fuzzy functional dependency and the basic propositions related to α value of fuzzy relation [1, 2], fuzzy closure of an attribute set that will be useful throughout the paper.

2.1 Fuzzy Set (FS)

Fuzzy set theory, introduced by Zadeh [4] in 1965 has been widely used in the areas where we have to deal with imprecise or ambiguous data. A fuzzy set is a generalization of a crisp set which is defined as follows: Let U be a classical set of elements, called the universe of discourse. An element of U is denoted by u .

Definition 1

A fuzzy set F in a universe of discourse U is characterized by a membership function $\mu_F : U \rightarrow [0,1]$ and F is defined as the set of ordered pairs $F = \{(u, \mu_F(u)) : u \in U\}$, where $\mu_F(u)$ for each $u \in U$ denotes the grade of membership of u in the fuzzy set F .

Note that a classical subset A of U can be viewed as a fuzzy subset with membership function μ_A that takes binary values, i.e.,

$$\begin{aligned} \mu_A &= 1 \text{ if } u \in A \\ &= 0 \text{ if } u \notin A \end{aligned}$$

2.2 Fuzzy Functional Dependency (FFD)

Next, to introduce the new notion of FFD as defined in [2], we give the following definitions and terminologies. Let X be a universal set and \mathfrak{R} be a fuzzy tolerance relation on X . Consider a choice parameter $\alpha \in [0,1]$ to be predefined by the database designer.

Definition 2

$(\alpha)_{\mathfrak{R}}$ -nearer elements.

Two elements $x_1, x_2 \in X$ are said to be $(\alpha)_{\mathfrak{R}}$ -nearer or α -nearer if $\mu_{\mathfrak{R}}(x_1, x_2) \geq \alpha$. We denote this by the notation $x_1 N_{(\alpha)_{\mathfrak{R}}} x_2$.

$(\alpha)_{\mathfrak{R}}$ -equality elements.

$x_1, x_2 \in X$ are said to be $(\alpha)_{\mathfrak{R}}$ -equal or α -equal if

$$x_1 N_{(\alpha)_{\mathfrak{R}}} x_2$$

Definition 3

$(\alpha)_{\mathfrak{R}}$ -equality of $t_1[X]$ and $t_2[X]$.

The equality notation is denoted as $t_1[X] \mathcal{E}_{(\alpha)_{\mathfrak{R}}} t_2[X]$ or simply by $t_1[X] \mathcal{E}_{\alpha} t_2[X]$.

Definition 4

Let $X, Y \subset R = \{A_1, A_2, \dots, A_n\}$. Choose a parameter $\alpha \in [0,1]$ and propose a fuzzy tolerance relation \mathfrak{R} .

A fuzzy functional dependency (FFD) is to be denoted by $t_1[X] \mathcal{E}_{\alpha} t_2[X]$, it is also the case that $t_1[Y] \mathcal{E}_{\alpha} t_2[Y]$.

2.3 Propositions

2.3.1 Proposition

$$t_1[X] \mathcal{E}_{\alpha} t_2[X] \Rightarrow t_2[X] \mathcal{E}_{\alpha} t_1[X].$$

2.3.2 Proposition

If $0 \leq \alpha_2 \leq \alpha_1 \leq 1$, then $X \rightarrow Y$ for α_1 and it implies to $X \rightarrow Y$ for α_2

2.4 Fuzzy Closure of Attribute Set (FCAS)

This fuzzy key can be actually computed using the concept of fuzzy closure of an attribute or set of attributes.

Fuzzy closure of an attribute set X denoted by X^+ is the set of attributes which are fuzzy functionally determined by the attributes X .

If the closure set X^+ is the minimal set which contains all the attributes of the relation scheme R , then the attribute set X is called the fuzzy key of the relation R . The fuzzy closure of an attribute or a set of attributes concepts are really helpful to minimizing the attribute set of a relation from large set by reducing redundant attributes[5,6].

2.5 Fuzzy Prime and Nonprime Attributes

In order to define fuzzy normal forms, we will also need the concepts of fuzzy prime and nonprime attributes for a relation. These are defined as follows:

Definition 5

Let $A \in R$ and K be a fuzzy key for R . A is called fuzzy prime attribute if and only if $A \in K$. Those attributes which are not fuzzy prime are called fuzzy nonprime attributes.

III. DEPENDENCY BASED ON MINIMAL COVER (DBMC)

The normalization process should also confirm the existence of two additional and desirable properties; dependency based minimal cover and lossless join property. Below we have designed algorithms that ensure that the dependency based on minimal cover properties is achieved by handling the minimal cover algorithm.

3.1 Minimal Cover

As I proceed to present the algorithms for the dependency preservation and lossless join properties, it would be essential to introduce the concept of minimal cover.

Definition 6

A minimal cover of a set of dependencies F , is a set of dependencies that is equivalent to F with no redundancies. A set of FFDs F is minimal if the following conditions hold:

- Every dependency in F has a single attribute for its right hand side.
- I cannot replace any FFD $X \xrightarrow{\alpha_1} A$ with $Y \xrightarrow{\alpha_2} A$ where $Y \subset X$ and $\alpha_2 > \alpha_1$.

I cannot remove any dependency from F and still have a set of FFDs equivalent to F . The algorithm below finds the minimal cover of a given FFD set and prepares the set without any partial FFD.

3.2 Minimal Cover Algorithm

Let A be the set of FFDs, and assign A to U , i.e. $U := A$.

Step1: Prepare right side atomicity

Replace each FFD $X \rightarrow \{A_1, A_2, \dots, A_n\}$ in U by n FFDs with α_1 .

Step2: Delete redundant left side attribute

For each FFD $X \rightarrow A_k$ in U with the dependant of α_1 and for each attribute $B \in X$ if $((U - \{X \rightarrow A_k; \text{depends on } \alpha_1\}) \cup ((X - \{B\}) \rightarrow A_k; \text{depends on } \alpha_2))$ where $\alpha_2 > \alpha_1$ is equivalent to U , then replace $X \rightarrow A_k$ depends on α_1 , with $(X - \{B\}) \rightarrow A_k$ depends on α_2 in U .

Step3: Delete any redundant FFD

For each remaining FFD $X \rightarrow A_k$, depends on α_1 in U

If $(U - \{X \rightarrow A_k; \text{ depends on } \alpha_1\})$ is equivalent to U, then remove $X \rightarrow A_k; \text{ depends on } \alpha_1$ from U.

Example

Let R= (A, B, X, Y, Z) and a set of FFDs

$F = XY \rightarrow ABZ, AY \rightarrow Z, A \rightarrow B, B \rightarrow Z$ for α_1 is 0.7, 0.7, 0.8 and 0.9 respectively. Find minimal cover of F.

Solution

Minimal cover algorithm is applied to get the minimal cover of F. U is initialized to the set of FFDs F i.e.,

$U = XY \rightarrow ABZ, AY \rightarrow Z, A \rightarrow B, B \rightarrow Z$ for α_1 is 0.7, 0.7, 0.8 and 0.9 respectively

Step1: Prepare right side atomicity

$U = XY \rightarrow A, XY \rightarrow B, XY \rightarrow Z, AY \rightarrow Z, A \rightarrow B, B \rightarrow Z$ for α_1 0.7, 0.7, 0.7, 0.7, 0.8 and 0.9 respectively.

Step2: Delete redundant left side attribute

From $A \rightarrow B$ with $\alpha_1=0.8$ and $B \rightarrow Z$ with $\alpha_1=0.9$, using FFD-transitive rule based on α , we get $A \rightarrow Z$ with $\alpha_2=0.8$ which implies $A \rightarrow Z$ with $\alpha_1=0.7$ using Proposition. Hence in $AY \rightarrow Z$ with $\alpha_1=0.7$, Y is a redundant attribute.

So $AY \rightarrow Z$ with $\alpha_1=0.7$ is replaced by $A \rightarrow Z$ with $\alpha_1=0.7$ in U.

Therefore $U = XY \rightarrow A, XY \rightarrow B, XY \rightarrow Z, A \rightarrow Z, A \rightarrow B, B \rightarrow Z$ for α_1 0.7, 0.7, 0.7, 0.7, 0.8 and 0.9 respectively.

Step3: Delete redundant FFD

The FFD $A \rightarrow Z$ with $\alpha_1=0.7$ is now redundant in U, since $A \rightarrow Z$ with $\alpha_1=0.7$ is obtained from $A \rightarrow B, B \rightarrow Z$ for FFD is 0.8 and 0.9 of U by using FFD-transitive rule based on α . So $A \rightarrow Z$ with $\alpha_1=0.7$ is removed from U.

Therefore $U = XY \rightarrow A, XY \rightarrow B, XY \rightarrow Z, A \rightarrow B, B \rightarrow Z$ for α_1 0.7, 0.7, 0.7, 0.8 and 0.9, is the minimal cover.

IV.CONCLUSION

Fuzzy relational database may data redundancy and anomalies if its schema is not perfect. Fuzzy functional dependency plays an important role in designing a good fuzzy relational database. Fuzzy functional dependency with the minimal cover algorithm help to identify and judgment the fuzzy database for its different form of fuzzy normalization.

Hope the fuzzy normalization which will be started based on minimal cover dependency of fuzzy relation.

Here I have concentrated on minimal cover algorithm based on dependency that ensure that duplicate or redundant dependency should be ignored for betterment of fuzzy relation which will be used for fuzzy normalization in future.

REFERENCES

- [1] S. Al-Hamouz, R. Biswas, "Fuzzy Functional Dependencies in Relational Databases", International Journal of Computational Cognition, Vol. 4, No. 1, pp. 39-43, 2006.
- [2] Mishra Jaydev and Ghosh Sharmistha, "A Study of Fuzzy Relational Database" International Journal of Computational Cognition, Vol. 6, No. 4, pp. 45-50, 2008.
- [3] E.F. Codd, "A Relational Model for Large Shared Data Banks", Comm. of ACM, Vol. 13, No. 6, pp. 377-387, 1970.
- [4] L.A. Zadeh, "Fuzzy Sets", Information and Control, Vol. 8, No. 3, pp. 338-353, 1965.

- [5] R. Belohlavek, T. Funiokova, V. Vychodil: “Fuzzy closure operators with truth stressers,” Logic Journal of IGPL 13(5)(2005), 503–513.
- [6] Daniel Borchmann, “Decomposing Finite Closure Operators by Attribute Exploration. In ICFCA 2011”, Supplementary Proceedings, 2011

AN EXPERIMENTAL ANALYSIS ON LIFE CYCLE OF TYRE RETREADING

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ABSTRACT

With the rapid development of automobile industry, scrap tyres producing substantially, the tyre retreaded has become a way of valuable and environmental recycling technology internationally recognized, and the need of promoting the energy conservation and emission reduction and the green recycling economy developing. However, the retreaded tyre lacks of systematic research in terms of technology theory, craft and detection, so the retreaded tyre of brings the destruction and failure of the tread, sidewall, ply, buffer layer and bead delaminating and cracking. The destruction and failure brings about the malfunctions of the tyre burst out of control, and the traffic accident of the moving vehicle. This seriously influences the application market of the retreaded tyre, and the person safety. The aim of this paper is to investigate the life of new and retreaded tyre. Retreading is one of the best process to increase the life of tyre. In practice, firms involved with commercial vehicles exploitation have to decide whether to retread used tyres or not, depending on the number of retreading of used tyres and travelled distances after each retreading. Analysis is performed on database of tyre's exploitation from a company of public passenger transportation and the statistical results are used as inputs to the proposed model. The results obtained according to the proposed model provide a good basis when it comes to making a decision whether to retread or not a used tyre. The experimental results show that retreading cost is 28% and life is 75% compare to new tyre. This paper gives the better approach of energy conservation.

Keywords : Retread, Buffing, Building, Vulcanised

I. INTRODUCTION OF TYRE

The tyres are required to carry the load of the automobile. The tyres may be with tube or tubeless. In the former, the tube is inside the tyre and contains air at high pressure. In tubeless tyre there is no tube and tyre itself contains air at high pressure. They also transfer the braking and driving torque to the road. The motion of the automobile becomes possible only when the friction acts between the tyre surface and the road surface. This friction is required for the stability of the moving automobile. The friction must not go beyond a particular limit as it will cause wastage of power output from the engine and loss of money in the form of wastage of fuel. The tyres also absorb the vibrations due to the uneven road surface. The road may be dry or wet, it may be a concrete road, or may be paved with gravel or asphalt. Sometimes automobile may be required to move on a 'rough' road. The tyres must be capable of providing stability to the automobile in all these varying conditions.

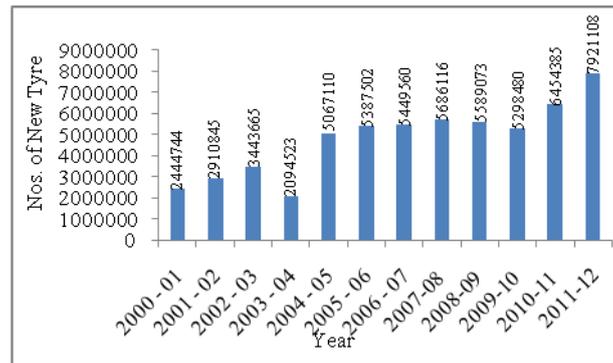


Fig. 1 Total nos. of New Tyre Production in India for F-2000-01 to F-2011-12 [30]

1.1 Types of tyre [1]

1. Tyre with Cotton (reinforcement) Carcass

In the starting phase of proper Bias or Cross ply tyre, cotton plies were used as main reinforcing material (end of 19th and early 20th Century). Cotton reinforcing material had inherent problems of low strength and high moisture regainer. Leading to large number of plies to get the requisite casing strength for the tyre weight of the tyre and poor heat dissipation. This, in turn, gave an adverse impact on Tyre weight and buck rendering poor performance.

2. Tyre with Nylon (reinforcement) Carcass

Persuent to development and introduction of Polymide (Nylon) the strength and flexing behavior of reinforcing materials improved substantially resulting in further reduction of number of plies, consequently the weight of the tyres. This development substantially improved the heat and impact resistance of the carcass leading to better tyre performance and higher durability. Nylon casing gave a boost to retreadability. Thus effective cost of the tyre in operation became much more economical.

Development of Tyre Technology due to change in Reinforcing material is basically in the case of Cross Ply or Bias Tyres. Bias tyre has cotton, Rayon or Nylon Cords, bound as plies and each ply (i.e. Cords) cross each other at a definite angle anchoring at the bead.

3. Radial (Construction) Tyre - Textile/Textile belt (Rayon/Nylon/Polyester)

Inspite of continuos development in Bias Tyre Technology, inherent problem of high heat development and poor life remains a continuos challenge.

In early 1950s new concept of Tyre design was developed namely "RADIAL" wherein plies were made highly flexible by keeping the cords at 90 and in order to improve tyre life, inextensible (stiff) belts were placed on the top of the Carcass under the tread. This led to stiffer tread portion, leading to higher Tread life (Mileage) and much more comfortable ride due to flexible carcass. This was the beginning of 'Revolution' in tyre technology.

Initially Radial tyres were introduced with Casing Plies as well as belt material of textiles.

Continuos development in Radial Concept led to further improvements as explained below.

4. Radial (Construction) Tyre - Textile/Steel belts

Once Steel Tyre cord got developed it found its immediate application in Belt material, keeping casing plies of Textile, to further improve durability.

5. Low Aspect Ratio (Cross Ply or Bias) Tyre

A new concept of low aspect ratio (ratio between section height and section width) of the tyre in cross ply construction was introduced for higher speed and better performance.

6. Tubeless Tyre (Cross Ply)

Concept of tubeless tyre in cross ply construction wherein an inner liner compound based on chlorobutyl or Halo Butyl which is impermeable to gases, was introduced eliminating the usage of tubes. However, Tubeless tyres are produced for Export Market. Gradually this concept will become fully acceptable with the advent of new generation vehicles and improved service facilities.

7. Radial (Construction) Tyre - All Steel

In developed countries, Radial Truck/Bus tyres use steel wires in casing as well as in Belts to achieve the optimum advantage of radial construction. In India also this construction was tried since late 1970s by Indian Companies using tyres of collaborators. This could not succeed.

Indian companies started experimentally since late 1980s (themselves or with collaborators) which continues and the product has found gradual entry into low load application.

II. TYRE RETREADING

It is very essential to know the meaning of 'tread'. The grooves which are cut on the tyre surface are called tread. These treads ensure the gripping action between the road surface and tyre. After the use of tyre the depth of treads becomes less and a slippery action takes place between road surface and tyre. The co-efficient of friction becomes less. A tyre is in no more condition to be used again. Now, here becomes the choice either to replace the tyre with a new one which is very expensive or to retread the tyre which is less expensive as compared to the cost of new tyre. 'Retreading' means taking a worn casing of good structural quality and putting it through a process which completely renews the tread of the tyre and sometimes the sidewall rubber. The rebuilt tyre is then subjected to a curing process where the new rubber is vulcanized to the casing and the tread pattern is formed. Retreading process can also rectify minor cuts or defects on the side walls of tyre, beads and punctures in a single stage. A tyre can be retreaded or not this is entirely dependable on the type of use of tyre and condition of tyre for example car tyres, 2 or 3 times; Light truck tyres 4 to 5 times; Heavy truck tyres 8 to 9 times; Air craft tyres upto 14 times. ^[3]

2.1 Why it is Required?

Over the years tyre manufacturers have invested heavily in product development to deliver tyres that not only have a 'first life' but are also designed to perform equally as well in subsequent second and even third lives. Stronger casings, improved re-manufacturing techniques, a variety of specialist rubber compounds, coupled with the need to recycle and reduce the negative impact on the environment has lead to a sustained growth in the retread industry.

Also to reduce the new manufacturing of tyre by using the old tyre. It gives an approach for energy conservation by saving the energy, material, man power, machine power and reduce the air pollution.

2.2 Benefits

- Commitment to the environment
- Reduce pollution
- Conserve oil
- Less energy

- Conserve resources

A retread tyre starts life as a worn tyre, where perhaps the tread is down to 2-3 mm and may have been previously re-grooved, or one that's been punctured and needs a repair.



Fig. 2 Effect of Tread Depth on Fuel Consumption Fuel savings at various tread wear level ^[24]

2.3 Process of Retreading ^[23]

1. Conventional Process (also known as 'mould cure' or 'hot cure' process)
2. Precure Process (also known as 'cold cure')

2.3.1 Conventional Process

- a) Tyre arrives in the workshop, it is cleaned thoroughly with water so, that dirt, dust and mud should all be removed effectively.
- b) Tyre is left for some time so that it may dry or a drier can be used for this purpose .
- c) Initial inspection is carried out to verify that casing is acceptable for retreading process or not. It is thoroughly examine inside and outside and marked with yellow coloured crayons.
- d) Buffing :- The primary objective of buffing is to prepare the worn out tread surface of tyre to receive a retread. The original tread design and the some of the under tread is also removed to provide the casing with required dimensions and surface texture. In other words it increases the co-efficient of friction of untread surface of tyre so that it can hold firmly the cushion and sole of new tread.
- e) A tyre is continuously rotating and a painting brush depth in vulcanized rubber solvent is placed over the surface of tyre. In this way it spreads uniformly. Take another dip of solvent if required. After the application of sufficient solvent a cushioning strip is fixed and tyre is slowly rotated so that complete circumference of tyre is covered and uncured tread compound is extruded or applied as a strip of sufficient length directly to the casing.
- f) The tyre is placed in a mould and air pressure is maintained so that it expands uncured material takes the position of the mould temperature of 150. C the tread and after some time the mould is opened and tyre is taken from the mould. These mould are used in the manufacture of new tyres. For every size of tyre a new mould is required so it is a expensive process and almost obsolete now a days.

A modern approach has been made in this section since last 20 - 25 years cols process retreading process has been becoming more popular and efficient due to is low cost, easy handling and more profit margins.

2.3.2 Precure Process

- a) Tyre arrives in the workshop, it is cleaned thoroughly with water so, that dirt, dust and mud should all be removed effectively.
- b) Tyre is left for some time so that it may dry or a drier can be used for this purpose.
- c) Initial inspection is carried out to verify that casing is acceptable for retreading process or not. It is thoroughly examine inside and outside and marked with yellow colored crayons.
- d) Buffing :-The primary objective of buffing is to prepare the worn out tread surface of a tyre to receive a retread. The original tread design and the some of the under tread is also removed to provide the casing with required dimensions and surface texture. In other words it increases the co-efficient of friction of untread surface of tyre so that it can hold firmly the cushion and sole of new tread.
- e) A tyre is continuously rotating and a painting brush depth in vulcanized rubber solvent is placed over the surface of tyre. In this way it spreads uniformly. Take another dip of solvent if required. After the application of sufficient solvent a cushioning strip is fixed and tyre is slowly rotated so that complete circumference of tyre is covered and uncured tread compound is extruded or applied as a strip of sufficient length directly to the casing.
- f) Now tyres are unloaded from the machines and hanged over hangers. The tyre envelope under a cover so that in the premould process the uncured cushion has to be vulcanized while pre mould tread has to be kept in position. Tyres from hangers are moved by hoists and chains and placed in fixed position in horizontal Autoclave. (Autoclave is a type of furnace). The air pressure nozzle tip is connected to envelope air pressure is maintained and lid of furnace is closed. A push button is switched on. A temperature of 99.C is maintained for 3-4 hours. This action creates an adhesive action between vulcanized coating, cushion pad and sole of treads. After 4 hours the electric supply is switched off and allow to cool in the furnace for 1 to 2 hours. The tyre is removed from the furnace and allowed to cool till the operator become able to remove the envelope.
- g) Final inspection:-To ensure that all the defects which were assigned before the process have been removed or not. If tyres pass the final inspection then; they are kept in warehouse for the requirement of supply.

III. EXPERIMENTAL ANALYSIS

3.1 Test Method

In order to find out the life cycle of retreading tyre, a novel test setup was designed and prepare by fabrication for particular tyre. The test setup is based on a tyre on tyre principle, which makes the setup quite simple and less expensive. Moreover, the tyre rolling deformation approaches better the deformation of a tyre rolling on a flat road. The test setup performs highly repetitive and controllable impact excitation tests under various operating conditions.



Fig. 3 Experimental Test Rig

The tyres used in the tests are radial tyres with symmetrical tread pattern of size 175/65R15 and the steel rims are rigidly clamped at the wheel hub. Figure 3 shows the test setup with the one tyre mounted. Since one identical tyre is used, the tyre deformations equal to the deformation of a tyre rolling on a flat road. The tyre is driven by a 2HP, three-phase induction motor.

The tachometer is used to measure the rpm of the wheel against different time in sec and load in mm. The tyre is mounted on the axle spindle which is connected to motor shaft with the help of pulley variac. The rotation speed is controlled by a pulley variac. Different speed was given by pulley and at different speed, the tyre was rotated and wear was measured in mm at different interval. Same procedure was done for new and retreaded tyre. I got tread wear against different speed and different load and compared the result for both tyre.

3.2 Test Results and Analysis

Table I. Input Parameter for Testing

Input Parameter For Testing	
Friction Coefficient (For rubber and dry smooth surface), μ	0.6
Aspect ratio	65
Tyre width, mm	175
Rim diameter, D_{rim} (mm)	381
Tyre O.D, D_{tyre} (mm)	608.5
Tread Depth (New), mm	8
Tread Depth (Retread), mm	8

Fig 4-5 show plots of travelling distance and tread wear. The normal pressure is distributed symmetrically around the centerline. The tyre surface and the track surface are both considered smooth.

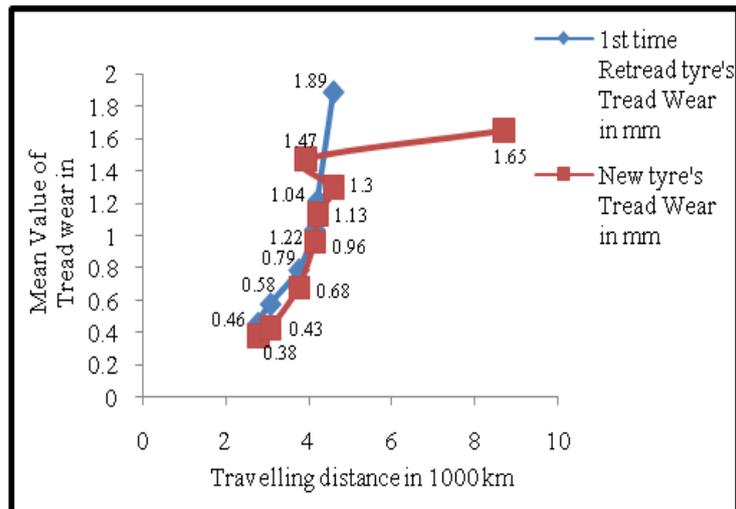


Fig. 4 Trend Line Representing the Mean Value of Tread Wear in mm for Different Travelling Distance of New and 1st Time Retreaded Tyre

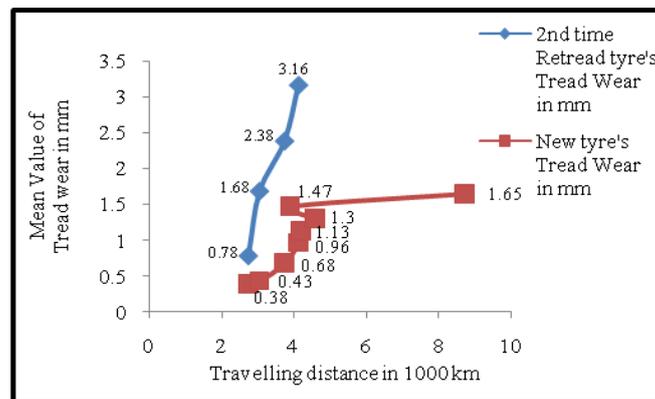


Fig. 5 Trend Line Representing the Mean Value of Tread Wear in mm for Different Travelling Distance of New and 2nd Time Retreaded Tyre

From above graphs it is concluded that the for same travelling distance of new and retreaded tyre, the tread wear is different, i.e the tread wear for new tyre is less than the retreaded tyre. Because the rubber ply is hard for new tyre and also the wear resistance is high for it. Whereas for retreaded tyre, the rubber ply is soft compare to new tyre and also the wear resistance is low for it.

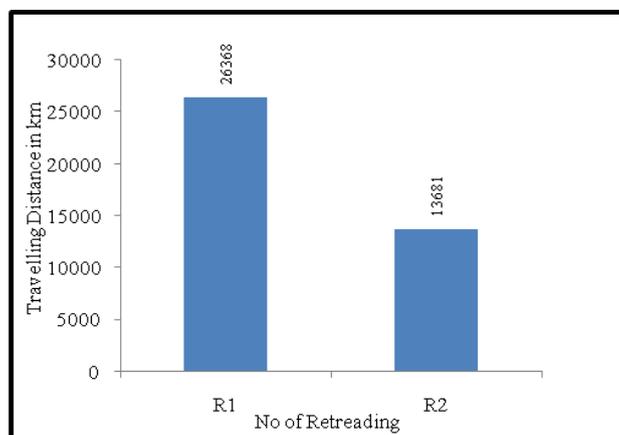


Fig. 6 Trend Lines Representing the Sum of the Total Travelled Distances in Function of Number of Retreading

By analysing the Fig.6 it can be noted that the travelling distance is decreasing by increase of number of retreading.

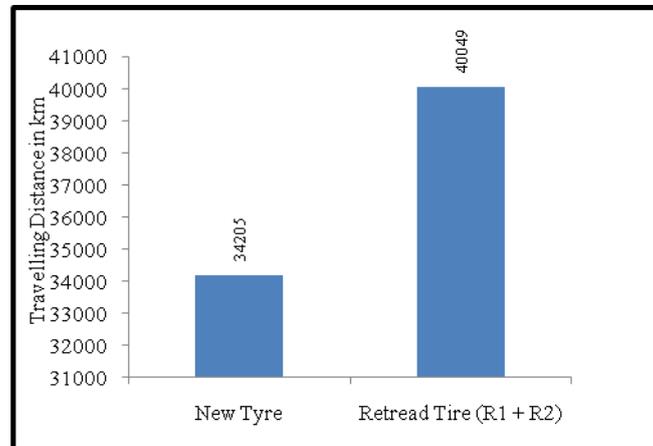


Fig.7 Comparison for Total Travelling Distance of Retreading and New Tyre

By analysing the Fig.7 it can be noted that the total travelling distance of retreaded tyre is more than that of new tyre.

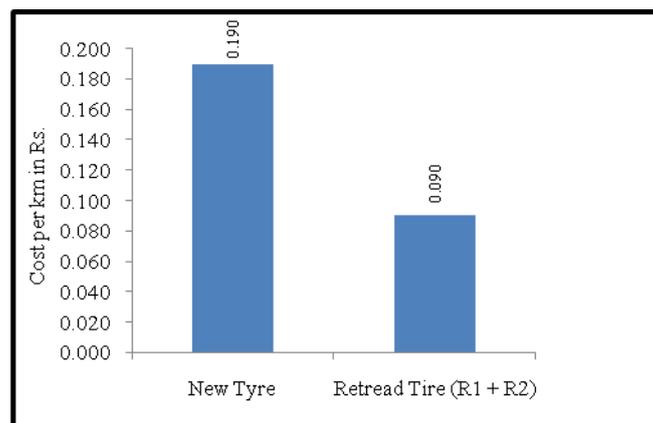


Fig. 8 Comparison for Total Cost Saving on Retreading and New Tyre

By analysing the Fig.8 it can be noted the cost per kilometer is less for retreaded tyre compare to new tyre because of we can do retreading on same tyre for number of times. Also the cost of retreading is 25-30% of the new tyre. So that the total travelling distance is more and cost per kilometer is less for retreaded tyre.

3.3 Model Limitation

The purpose of the model is to provide a simple approximate solution in situations. The difficulty arises because the displacement at any point in a contact surface depends on the pressure distribution throughout the whole contact. This difficulty is avoided if sets up the contact as a foundation of springs or bristles, and ignores the interaction between them. The contact pressure at any contact point then depends only on the displacement at that point. The contact calculations can thereby be done much easier and faster. The compliance of the two surfaces involved in the contact (in this case only the tyre that deforms) is not so well modeled, since the deformations outside the contact is neglected. The jerk between tyre and track is negligible during whole experiment.

3.4 Further Improvements

Further improvements in accuracy can be made. A more accurate contact pressure distribution in both longitudinal and lateral direction, would give an improved model. In this paper, the tyre is considered to be cylindrical with equally distributed contact pressure in lateral direction. In reality, the pressure is higher in the sidewall area than further into the contact. The distribution also depends on aspect ratio and tread pattern. Road roughness should also be included in the contact calculations to increase the accuracy.

IV. CONCLUSION

- Retreading is an established and well-regulated process for producing high quality remanufactured tyres. Retreaded tyres are subject to stringent quality certification that matches new tyre regulations.
- Because tyre casings are so thoroughly inspected and tested and because the precured tread or mould cure rubber compound is chosen with the projected use in mind, retreaded tyres often have a longer life than new tyres and can have a lower rate of failure.
- Tyre retreading saves raw material that is rubber. A tyre is made up of 100% rubber approx. as main ingredient 20% is only used in worn out tyres rest 80% is tyre carcass.
- The retreading cost can be about 28% of the new tyre. Also the retreaded tyre have 77% life from 28% cost compare to new tyre and 2nd time retreaded tyre have 40% life from 28% cost.

The presented results show that the test setup performs highly repetitive and controllable impact excitation tests under various operating conditions. Although the test setup is limited to high speeds, the most important mechanisms and influences can be studied. A tyre model, based on modal parameters, should take into account this softening effect which is dependent on the tyre construction.

- From above graphs it is concluded that the total travelling distance of retreaded tyre is more than new tyre and the cost per kilometer is less than new tyre. Because we can do number of times retreading on same tyre. So that by using the retreaded tyre we can save the energy which is using to manufacturing the new tyre. Also with the help of this we can control the pollution.
- The retreaded tyre is not used for costly and precise item's transportation for safety point of view.

V. ACKNOWLEDGMENT

On the day of presenting a seminar on "An Experimental Analysis on Life Cycle of Tyre Retreading", I hereby take this opportunity to express my thankfulness towards all the persons who either knowingly or unknowingly helped my cause.

REFERENCES

- [1]. Anurag Sharma, "Retreading of Tyres", International Journal of Engineering and Advanced Technology (IJEAT), ISSN: 2249 – 8958, Volume-2, Issue-6, August 2013
- [2]. Henri Lecouls et al, "Note on the critical review of the study Life Cycle Assessment for the different used tyres recycling methods", Ecobilan, Int J Life Cycle Assess, 2010
- [3]. Pieter J.H. et al, "Trade and recycling of used tyres in Western and Eastern Europe", Elsevier Ltd, 2001

- [4]. Mohamed Gomma Elnour et al, "Tyre Hazardous, Disposal and Recycling", Journal of Applied and Industrial Sciences, 2014, 2 (2): 63-74, ISSN: 2328-4595 (PRINT), ISSN: 2328-4609 (ONLINE)
- [5]. WANG Hui-zhi et al, "Review of Waste Tyre Reuse & Recycling in China", Advances in Natural Science ISSN 1715-7862 Vol.2, No.1, 2009
- [6]. Svetlana Dabić-Ostojic et al, "Applying a mathematical approach to improve the tyre retreading process", Elsevier Ltd, 2013
- [7]. Geraldo Ferrer et al, "The economics of tyre remanufacturing", Elsevier Ltd, 1996
- [8]. Qi Xiao-jie et al, "Study on the Prediction Technology of the Retreaded Tyre Residual Life", Scientific and technological research projects in Heilongjiang Province, 2008
- [9]. Mr. Mukund Pandya et al, "Determination of Time Delay and Rate of Temperature Change during Tyre Curing (Vulcanizing) Cycle", Elsevier Ltd, 2013
- [10]. Julius I. Osayiet et al, "Review Article : Biocrude Production through Pyrolysis of Used Tyres", Hindawi Publishing Corporation, 2014
- [11]. Ari J. Tuononen, "Vehicle Lateral State Estimation Based on Measured Tyre Forces", sensors, ISSN:1424-8220, 2009
- [12]. Jin Changa et al, "FE simulation of tyre wear with complicated tread pattern", Elsevier Ltd, 2011
- [13]. Wang Qiang et al, "Study on the Ground Mechanical Characteristics of Load Vehicles Retreaded Tyres", IEEE, 2011
- [14]. N.S.I.C Okhla Phase-III, New Delhi, consultation entrant Workshop-II, Okhla (DTC) apprentice ship Training Revision of rates of preparation Small industries service Institute (Sikkim) December-2002.
- [15]. Bruce Taylor, Encouraging industry to assess and implement cleaner production measures, Environmental Stewards Inc. Elmira, Ontario, Canada, (2006).
- [16]. Environmental Protection Agency Frequently Asked Questions about Recycling and Waste Management. Retrieved 18 October (2006).
- [17]. Van de clundert, A. and Anschutz. J. —Integrated sustainable waste management, Amsterdam, Netherlands, (2001).
- [18]. Des W. Connell, Gregory J. Miller, —Chemistry and Ecotoxicology of Pollution, Publisher: Hardcover New York, April (1984).
- [19]. Joseph Anthony Salvato, Environmental Engineering and Sanitation, McGraw-Hill. New York, USA, (1994).
- [20]. Ackerman, Frank. "Why Do We Recycle?: Markets, Values, and Public Policy", Island Press. ISBN 1-55963-504-5, ISBN 978-1-55963-504-2, (1997).
- [21]. Serop Kalpakjian, Steven R. Schmid Manufacturing Engineering And Technology. Prentice Hall, Mexico City, Munich, Paris, Capetown, Hong Kong, Montreal, JANUARY (2009).
- [22]. Ayres, R.U. "Industrial Metabolism: Theory and Policy", In: Allenby, B.R., and D.J. Richards, "the Greening of Industrial Ecosystems", National Academy Press, Washington, DC, pp. 23-37. (1994).
- [23]. Technical discussion with Mr. Navin Ravat, AWS, Tyre Retreading plant, S.T Workshop, Bholav, Bharuch, Gujarat, India.
- [24]. Tyres and truck economy a new perspective, 4th edn, bridgestone
- [25]. K.K Jain and R.B Asthana in Automobile Engineering, Tata McGraw-Hill, chapter-19, pp-318-331

- [26]. R.K Rajput in A Text Book of Automobile Engineering, 1st Edn, Laxmi Publication Pvt. Ltd, 2007, pp 442-452.
- [27]. K.M.Gupta in Automobile Engineering part-1, 2nd edn, Laxmi publication
- [28]. Titty in Automobile Engineering, 1st edn, Laxmi publication, 2009, pp128-136
- [29]. Martin McMahon in Trade of Motor Mechanic, CDX global, Module-7, unit 1, Wheels & Tyres, 2007, pp 1-16
- [30]. S. Srinivasan in Automotive Mechanics; 2nd edn; Tata Mcgraw-hill, 2003, pp 57-66
- [31]. Sudhir kumar saxena in Automobile Engineering; 1st edn; Laxmi publication, 2009, pp128-136
- [32]. <http://www.atmaindia.org/Technology.htm>
- [33]. http://www.atmaindia.org/Cur_Statistics.htm
- [34]. <http://www.aryanmachinery.com>

REVIEW PAPER

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ABSTRACT

Now days, due to many factors people around the globe are neglecting their health and are suffering from many diseases. The reasons of these are many that include relying on fast foods, unhealthy eating habits, work pressure etc. To combat the medical problems, despite of their busy schedules people visits hospitals and health care clinic. To save their times and efforts, Health Recommender Systems (HRS) have been employed in health care field. This system provides support to ill people in many ways. Many researchers have found out different HRS based on different algorithms. This paper is an attempt to review some papers based on HRS.

Keywords: Diseases, Eating Habits, Health Care, Health Recommender Systems, Symptoms

I. INTRODUCTION

Since people are neglecting their health due to busy work schedule and other reasons, their deteriorating health has become a serious issue. According to surveys in The United States of America conducted by PewResearch Internet Project [2], it has been shown that one in three American adult have gone online to search for information about some medical condition. Many individuals are now moving towards internet for consulting about their medical conditions. Some may search for the symptoms on the internet or share among social networking sites [2]. Hence in order to facilitate the user, recommending systems have been deployed so that an easy counseling can be done on the basis of the information provided by the user. The recommender systems are based on three aspects: the content based approach, collaborative approach and data mining algorithms. The papers have also explained the future aspects of their works and the challenges and opportunities for the same. The detail explanation is given below.

II. HEALTH RECOMMENER SYSTEM

A recommender system is a system that suggests items of interest of user [4]. A health recommender system is a system developed that will recommend various desired options that may suite to the inquiry as asked by the user. It is characterized by the information given by the user, asked by the user and the solution that can be given to the user based on many algorithms used. Many researchers [5,6,7] have argued that if the information given by the user about his/ her medical problem, his diagnosis reports details can be clubbed with many medical sites (FedMed etc.), recommendations can be given that can ease the user. The types of approach that can be used to design a health recommender system are :

1. Content based approach (that works on the ratings given by a number of users to a number of products in the past).
2. Collaborative approach (try to determine other users that have inquired the same text as the user).
3. Information retrieval.

4. Hybrid approaches.

Since sharing information regarding an individual's medical problem is a personal choice, collaborative approach is not highly recommended in health recommender systems. Despite of many challenges, recommender systems have found their way in health care field and in personal health systems that deals with providing information trade-off between doctor and patient. Since health recommender systems have many models many authors have adopted different algorithms in designing different recommender systems.

III. SURVEY REPORT

The PewResearch Internet survey has conducted survey in The United States of America regarding the usage of internet to gather information regarding some medical condition [2]. It has been found by the survey that a large number of adults are searching internet for symptoms, diagnosis and recommendation on internet about some medical conditions either for themselves (39%) or for others (39%). The survey has also portrait that many found that their findings on the internet has been confirmed by the consultant doctors (41%). Many found that some findings have been denied (18%) and many did not consult to the concerned physician (35%). Hence the paper has shown that internet has become an important aspect of consultation for the medical help among adults of USA. This also shows that people are searching for health care data about those who are showing the same symptoms as they are. Hence it can be inferred that adults are initially diagnosing regarding their health issues on internet before going for the consultations of the doctor.

IV. USE OF HRS IN MEDICAL FIELD

Different models of the health recommender systems have been suggested to combat problems that are lifelong. The author of the paper [1] has suggested use of recommender systems for the parents of the children that are suffering from Autism. Autism is a lifelong situation in which a person shows different symptoms. It has been suggested that use of social sites can facilitate clinics and parents of such children to communicate with other families and can share some of their problems and can get the recommendations regarding the problem. The author has also suggested that this will lead to a healthy communication between the families and they can then share their progresses and difficulties on the social network operated by the use of mobile phones. The use of SVM (Support Vector Machines) has been shown. SVMs [8] are based on structural risk minimization principal. Author has also conducted experiments related to autism behavior. The different symptoms shown by the autistic children are categorized and some sets are formed giving values to the most used words. The explanations derived from the experiments can be used to assess the problems given by the parents and then it can easily grouped and recommendations can be made. The method used by the author was machine learning and approach given by author was explanation based.

Recommender systems also find its existence in conditions regarding eating habits of people. The author of paper [3] has suggested that recommender systems can be deployed in giving recommendations to the people about the food that are good for them and bad for them. The approach given by the user is both content based and collaborative based. The author has given the procedure as the information given by the user about their heating plans, the data mining algorithm and then the healthy food recommendations. The traditional information retrieval technique is used to facilitate the user in obtaining information. The database design is

done by using HTTP. It has been shown that a recommender system can be develop using website that can take orders from the user and can give information to them about the food that are healthy and good for them.

V. CONCLUSION

The papers that have been reviewed are based on use of health recommender systems and give different models to design HRS. use of internet and social networking sites have also shown. The survey conducted in the paper gives information about the inclination of the adult towards internet for their personal diagnosis before going to clinic. Hence it can be concluded that health recommender systems are gaining their places in health care field and use of them will facilitate a user about the information that is been searched.

VI. FUTURE WORK

The approach given in the paper can be used differently to design many health recommender systems for different use. Medical field is too vast that scope of recommender system is large enough for more research and more models. Many models can be hybrid together to open up gates for the user to seek information about many dimensions in one model.

VII. LITERATURE SURVEY

The literature is taken from the papers under review. Help is also taken from the cross references of the papers. Internet is also been searched for the cross checking of the information in the papers. Wikipedia is consulted for the technical terms in the papers. Search engines like Google and Yahoo has been used.

REFERENCES

- [1]. Insu Song, Denise Dillon, Tze Jui Goh, and Min Sung; “A health social network recommender system”; D. Kinny et al. (Eds.): PRIMA 2011, LNAI 7047, pp. 361–372, 2011. Springer-Verlag Berlin Heidelberg 2011.
- [2]. Susannah Fox, Maeve Duggan; PewResearch Internet Project.
- [3]. Shilpa Dharkar, Aanand Rajavat; “Web data mining for designing of Healthy Eating Systems” ; International Journal of Internet Computing, Volume-I, Issue-1, 2011.
- [4]. Martin Wiesner, Daniel Pfeifer ; “Health Recommender Systems: Concepts, Requirements, Technical Basics and Challenges”; Int J Environ Res Public Health. Mar 2014; 11(3): 2580–2607. Published online Mar 3, 2014. doi: 10.3390/ijerph110302580.[Cross Ref]
- [5]. Eysenbach G., Köhler C; “How do consumers search for and appraise health information on the world wide web?”;Qualitative study using focus groups, usability tests, and indepth interviews. Br. Med. J. 2002;324:573. doi: 10.1136/bmj.324.7337.573. [PMC free article] [PubMed] [Cross Ref].
- [6]. Eysenbach G.; “ Design and Evaluation of Consumer Health Information Web Sites.”; Consum. Health Inform. 2005 doi: 10.1007/0387276521_4. [Cross Ref].
- [7]. Zhang Y.; “ Contextualizing Consumer Health Information Searching: An Analysis of Questions in a Social Q&A Community”; Proceedings of the 1st ACM International Health Informatics Symposium (IHI '10), ACM; New York, NY, USA. 11–12 November 2010; pp. 210–219.[Cross Ref]

[8].Cortes, C., Vapnik, V.: Support-vector networks. Machine Learning 20(3), 273–297 (1995).[Cross Ref]

A BRIEF REVIEW ON MG ALLOYS THEIR PROPERTIES AND APPLICATION

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ABSTRACT

Magnesium is the lightest of all light metal alloys and therefore is an excellent choice for engineering applications when weight is a critical design element. It is strong, has good heat dissipation, good damping and is readily available. The use of pure magnesium is rare due to its volatility at high temperatures and it is extremely corrosive in wet environments. Therefore the use of magnesium alloys when designing aerospace and automotive parts is critical. Specific alloys are better for certain applications and often also need a coating to provide the longest life of the part. This paper details specific alloys Properties and Their application.

Keywords: Magnesium alloys, alloying elements, Mechanical properties , physical properties.

I. INTRODUCTION

Magnesium is an excellent metal as it is readily available commercially and it is the lightest of all the structural metals having a density of 1.7g/cm³; it also has good heat dissipation, good damping and good electro-magnetic shield. It is most commonly found in the earth's ocean. Magnesium has a moderately low melting temperature making it easier to melt for casting. Additionally it is relatively unstable chemically and extremely susceptible to corrosion in a marine environment. It is thought that the corrosion is due more to impurities in the metal versus an inherent characteristic. Finally magnesium powder ignites easily when heated in air and must be handled very carefully in a powder form. The rest of this section will review the advantages and disadvantages to magnesium use in engineering applications. In addition, alloy types and an introduction to coating protections will be discussed.

Magnesium and magnesium alloys are primarily used in aeronautical and automobile industry in wide variety of structural characteristics because of their favorable combination of tensile strength (160–365MPa), elastic modulus (45 GPa), and low density (1740 kg/m³, which is two-thirds that of aluminum). Magnesium alloys have high strength-to-weight ratios (tensile strength/density), comparable to those of other structural metals. Magnesium has relatively good electrical conductivity and thermal conductivity. It also has a very high damping capacity that means, the ability to absorb elastic vibrations. Alloys containing yttrium exhibit good corrosion resistance.

Pure magnesium is rarely used in the manufacturing of aerospace and automotive parts. In order to be used in manufacturing, it is alloyed with other metals. Some of the most common alloyed elements in commercial alloys are: aluminum, zinc, cerium, silver, thorium, yttrium and zirconium. In order to name magnesium alloys, the American Society for Testing Materials developed a method for designating the alloys. The first two letters indicate the principal alloying elements according to the code listed in Table 1. The one or two letters are

followed by numbers which represent the elements in weight % rounded to the nearest whole number. For example AZ91 indicates the alloy Mg-9Al-1Zn

Code Letter	Alloying Element
A	Aluminum
B	Bismuth
C	Copper
D	Cadmium
E	Rare Earth
F	Iron
G	Magnesium
H	Thorium
K	Zirconium
L	Lithium
M	Manganese
N	Nickel
P	Lead
Q	Silver
R	Chromium
S	Silicon
T	Tin
W	Yttrium
Y	Antimony
Z	Zinc

II.ROLE OF ALLOYING ELEMENTS IN MG-AL ALLOYS

2.1 Aluminum

Aluminum is the most widely used additive in magnesium alloys. The Mg-Al alloys are considered to have reasonable mechanical properties. The maximum solid solubility of aluminum in magnesium is 12.7wt% at 437°C. Aluminum provides solid solution strengthening, and at greater than 2wt%, precipitation of the β phase occurs which further enhances hardening. Al in this alloy also improves the castability and fluidity. However, Al also increases the tendency for shrinkage micro porosity up to 9% and then reduces it. The reason for the peak porosity at 9% can be related to the worst combination of mushy zone size, interdendritic feeding, permeability and eutectic volume fraction. Aluminum also increases the corrosion behavior of Mg-Al alloys.

2.2 Zinc

Zinc is often said to be added to Mg-Al alloys to impart solid solution strengthening and improved fluidity. But higher amount of Zn in Mg- Al alloys can lead to hot cracking problem. It is further reported that the addition of zinc reduces the ductility of the alloy. Zinc strongly affects solidification pattern of AZ91 alloy thereby forming micro-porosity. It is reported that addition of 2% Zn increases micro porosity in sand-cast magnesium alloys containing 2, 4, 8 and 10% Al. It has also been reported that, zinc widens the two phase α -Mg and β -Mg₁₇Al₁₂

field which may result in a higher degree of precipitation and a corresponding increase in strength in age hardened alloys. Zinc may also have a role to play in accelerating the rate of precipitation in age hardening.

2.3 Manganese

Manganese is added to magnesium alloys in small quantities approximately 0.2wt% to improve the corrosion resistance by removing cathodic impurities such as Fe through the formation of intermetallic compounds which are precipitated out of the melt prior to casting. This leaves the alloys far less sensitive to local galvanic corrosion. The exact amount of Mn addition into Mg-Al alloys is dependent on the chemical compositions and the casting conditions of each alloy. Manganese is predominantly present in the microstructure of Mg-Al alloys in the form of intermetallics such as Al₁₈(Mn,Fe)₅ and α -AlMnFe.

III.COMPOSITION OF ALLOYING ELEMENTS IN MG-AL ALLOYS

Commercial:	Magnesium Die Casting Alloys ^(A) ^(F)						
	AZ91D ^(A)	AZ81 ^(B)	AM60B ^(B)	AM50A ^(B)	AM20 ^(B)	AE42 ^(B)	AS41B ^(B)
Nominal Comp:	Al 9.0 Zn 0.7 Mn 0.2	Al 8.0 Zn 0.7 Mn 0.22	Al 6.0 Mn 0.3	Al 5.0 Mn 0.35	Al 2.0 Mn 0.55	Al 4.0 RE 2.4 Mn 0.3	Al 4.0 Si 1.0 Mn 0.37
Detailed Composition							
Aluminum Al	8.3-9.7	7.0-8.5	5.5-6.5	4.4-5.4	1.7-2.2	3.4-4.6	3.5-5.0
Zinc Zn	0.35-1.0	0.3-1.0	0.22 max	0.22 max	0.1 max	0.22 max	0.12 max
Manganese Mn	0.15-0.50 ^(C)	0.17 min	0.24-0.6 ^(C)	0.26-0.6 ^(C)	0.5 min	0.25 ^(D)	0.35-0.7 ^(C)
Silicon Si	0.10 max	0.05 max	0.10 max	0.10 max	0.10 max	–	0.5-1.5
Iron Fe	0.005 ^(C)	0.004 max	0.005 ^(C)	0.004 ^(C)	0.005 max	0.005 ^(D)	0.0035 ^(C)
Copper, Max Cu	0.030	0.015	0.010	0.010	0.008	0.05	0.02
Nickel, Max Ni	0.002	0.001	0.002	0.002	0.001	0.005	0.002
Rare Earth, Total RE	–	–	–	–	–	1.8-3.0	–
Others Each ^(E)	0.02	0.01	0.02	0.02	0.01	0.02	0.02
Magnesium Mg	Balance	Balance	Balance	Balance	Balance	Balance	Balance

IV. MECHANICAL AND PHYSICAL PROPERTIES OF ALLOYING ELEMENTS IN MG-AL ALLOYS

Commercial:	Magnesium Die Casting Alloys						
	AZ91D	AZ81	AM60B	AM50A	AM20	AE42	AS41B
Mechanical Properties							
Ultimate Tensile Strength ^(B) ksi (MPa)	34 (230)	32 (220)	32 (220)	32 (220)	32 (220)	27 (185)	33 (225)
Yield Strength ^{(E) (B)} ksi (MPa)	23 (160)	21 (150)	19 (130)	18 (120)	15 (105)	20 (140)	20 (140)
Compressive Yield Strength ^(H) ksi (MPa)	24 (165)	N/A	19 (130)	N/A	N/A	N/A	20 (140)
Elongation ^(B) % in 2 in. (51mm)	3	3	6-8	6-10	8-12	8-10	6
Hardness ^(F) BHN	75	72	62	57	47	57	75
Shear Strength ^(B) ksi (MPa)	20 (140)	20 (140)	N/A	N/A	N/A	N/A	N/A
Impact Strength ^(D) ft-lb (J)	1.6 (2.2)	N/A	4.5 (6.1)	7.0 (9.5)	N/A	4.3 (5.8)	3.0 (4.1)
Fatigue Strength ^(A) ksi (MPa)	10 (70)	10 (70)	10 (70)	10 (70)	10 (70)	N/A	N/A
Latent Heat of Fusion Btu/lb (kJ/kg)	160 (373)	160 (373)	160 (373)	160 (373)	160 (373)	160 (373)	160 (373)
Young's Modulus ^(B) psi x 10 ⁶ (GPa)	6.5 (45)	6.5 (45)	6.5 (45)	6.5 (45)	6.5 (45)	6.5 (45)	6.5 (45)
Physical Properties							
Density lb/in ³ (g/cm ³)	0.066 (1.81)	0.065 (1.80)	0.065 (1.79)	0.064 (1.78)	0.063 (1.76)	0.064 (1.78)	0.064 (1.78)
Melting Range ³ F (°C)	875-1105 (470-595)	915-1130 (490-610)	1005-1140 (540-615)	1010-1150 (543-620)	1145-1190 (618-643)	1050-1150 (565-620)	1050-1150 (565-620)
Specific Heat ^(B) BTU/lb °F (J/kg °C)	0.25 (1050)	0.25 (1050)	0.25 (1050)	0.25 (1050)	0.24 (1000)	0.24 (1000)	0.24 (1000)
Coefficient of Thermal Expansion ^(B) μ in/in °F (μ m/m °K)	13.8 (25.0)	13.8 (25.0)	14.2 (25.6)	14.4 (26.0)	14.4 (26.0)	14.5 ^(G) (26.1)	14.5 (26.1)
Thermal Conductivity BTU/ft hr °F (W/m °K @)	41.8 ^(C) (72)	30 ^(B) (51)	36 ^(B) (62)	36 ^(B) (62)	35 ^(B) (60)	40 ^{(B) (G)} (68)	40 ^(B) (68)
Electrical Resistivity ^(B) μ Ω in. (μ Ω cm.)	35.8 (14.1)	33.0 (13.0)	31.8 (12.5)	31.8 (12.5)	N/A	N/A	N/A
Poisson's Ratio	0.35	0.35	0.35	0.35	0.35	0.35	0.35

V. RECENT TRENDS IN MG ALLOYS AND APPLICATION

5.1 Automotive Applications

The magnesium industry has made great efforts to educate the automotive industry on the benefits of utilizing magnesium to reduce vehicle weight, cost, and/or complexity. Applications of magnesium in automobiles using the die casting approach has been in components such as instrument panels, steering wheels, steering columns and seat risers which take advantage of magnesium's high strength-to density ratio & excellent ductility combined with attractive energy absorbing characteristics. Magnesium parts in production include: accessory drive brackets (AZ91D), automatic transmission clutch piston and stator (AS41B), clutch housing (AZ91D), door mirror brackets (AZ91D), headlamp retainers (AZ91D), upper and lower inlet manifolds (AM60B, AZ91D), oil filter adapter housing (AZ91D), power window regulator housings (AZ91D), seat frames

(AM60B), steering wheel armatures (AM50 [Mg-5Al-0.3Mn], AM60B) and valve and cam covers (AZ91D). Fig.1 shows some of the automotive components made from magnesium alloys.



Fig.1: Some of the Major Magnesium Based Automotive Components

5.2 Aerospace Applications

Magnesium has seen quite extensive use in both civil and military aircrafts. Some applications include the thrust reverser (for Boeing 737, 747, 757, 767), gearbox (Rolls-Royce), engines, and helicopter transmission casings, etc. Military aircraft, such as the Euro fighter Typhoon, Tornado, and F16, also benefit from the lightweight characteristics of magnesium alloys for transmission casings. There is also widespread use of magnesium in spacecraft and missiles due to the requirement for lightweight materials to reduce the lift-off weight. This is coupled with its high specific mechanical properties, ease of fabrication, and other attractive features such as its capability to withstand (i) elevated temperatures, (ii) exposure to ozone, and (iii) bombardment of high-energy particles and small meteorites. Alloys such as ZE41 (Mg-4.2% Zn-0.7% Zr-1.3% MM), QE22 (Mg-0.7% Zr-2.5% Nd-2.5% Ag) and particularly WE43 (Mg-4% Y-3.25% Nd-0.5% Zr) are commonly used for aircraft applications due to their improved corrosion and creep resistance. Fig.2 gives some of the aerospace components made from magnesium alloys.



Fig.2: Some of the Aerospace Components Made up of Mg Alloys

5.3 Nuclear Industry

With natural uranium as a fuel, it is essential to conserve neutrons by only using materials in the reactor which will not absorb them readily. Natural uranium plants with operating temperatures suitable for power production essentially determine the general reactor design and limit the casing material to magnesium and the coolant gas to magnesium dioxide. The advantages of magnesium over competing materials are: (a) low tendency to absorb neutrons, (b) does not alloy with uranium, (c) adequate resistance to carbon dioxide up to the highest service temperatures envisioned, and (d) good thermal conductivity.

5.4 Sports Applications

The excellent specific strength and ability of magnesium alloys and magnesium composites to form intricate shapes resulted in many applications in sports-related equipment. For example, magnesium-based materials are used in the handles of archery bows, tennis rackets, and golf club heads. The lightweight and excellent damping characteristics of magnesium-based materials have also made them a popular material choice in bicycle frames and the chassis of in-line skates. Fig.3 gives some of the sports components made from magnesium alloys.

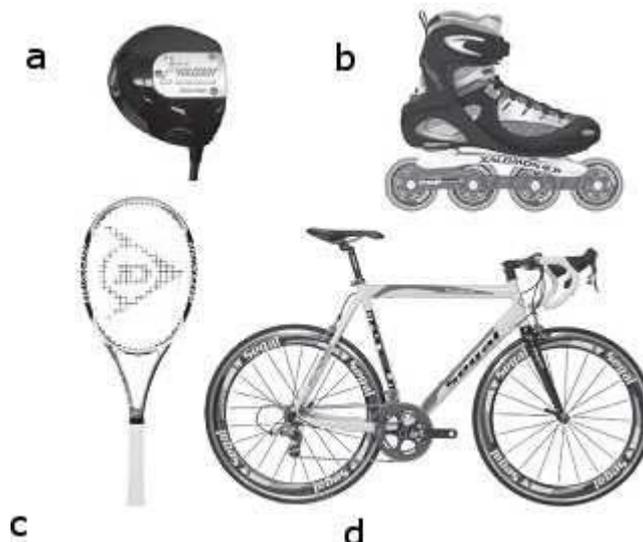


Fig.3: Magnesium sports equipments: (a) golf club head, (b) in-line skates with magnesium chassis, (c) tennis racket with magnesium head and (d) bicycle with magnesium frame

5.5 Electronic Applications

In spite of automobile and aerospace components, magnesium also finds application in electronics items. Magnesium-based materials are used in housings of cell phones, computers, laptops, and portable media players. The ability to form magnesium alloys into complex shapes and the good heat dissipation and heat transfer characteristics of magnesium alloys also result in the use of magnesium alloys in heat sinks and the arms of the hard-drive reader. Other examples of the use of magnesium include the housings of cameras and digital image projection systems.

5.6 Medical Applications

Magnesium alloys were first introduced as orthopedic biomaterials in the first half of the last century. However, due to its low corrosion resistance, a large amount of hydrogen accumulates around the implant during the *in-vivo* corrosion process, confining the widespread use of magnesium-based materials as biomaterials. Despite,

magnesium still possesses many attractive characteristics that make magnesium based materials potential candidates to serve as implants for load-bearing applications in the medical industry. Magnesium is also present as a natural ion in the human body, whereby approximately 1 mol of magnesium is stored in a 70 kg adult human body and an estimated amount of half of the total physical magnesium is present in the bone tissue. It also assists in many human metabolic reactions and is nontoxic to the human body. Magnesium has good biocompatibility and it is biodegradable in human body fluid by corrosion, thus eliminating the need for another operation to remove the implant. All these desirable features make magnesium-based material a promising implant material.

VI. CONCLUSION

Magnesium is a critically important metal in design of aerospace and automotive parts because of its desirable mechanical properties. The low density, good heat dissipation, good damping and good electro-magnetic shield all make it a top choice for design of aerospace and automotive parts. However, the varying operational environments require a material that is more corrosion resistant. Therefore, magnesium is alloyed with other materials (metals and rare earth elements) to provide the best material for aerospace and automotive parts.

This paper provided the selection of an alloy type depends on how the part will be made (cast or wrought), the strength required, and the operational environment. There are other considerations made in designing each specific part to help select between several very similar alloys. This paper documents a number of different alloys that can be used for aerospace and automotive applications.

REFERENCES

- [1]. L. Čížek, et. Al. -Study of selected properties of magnesium alloy AZ91 after heat treatment and forming, 2004 Elsevier.
- [2]. R.z. wu, et. Al.- Review on the influences of alloying elements on the microstructure and mechanical properties of Mg-Li based alloy.
- [3]. Aghion, E., Bronfin, B., & Von, Buch. F. (2003). Newly developed magnesium alloys for powertrain applications. . Journal of Metals, 55, 2003.
- [4]. Avadesian, M. M., Baker, Hugh., & (editors, . (1999). Magnesium and Magnesium Al-loys, ASM Specialty Handbook (Materials Park, OH: ASM International)
- [5]. Callister Jr., William D. Materials Science and Engineering An Introduction. New York: John Wiley & Sons Inc. 2007
- [6]. Shackelford, James. Introduction to Materials Science for Engineers. Upper Saddle River: Pearson Prentice Hall, 2005.
- [7]. Polmear, I. Light Alloys from Traditional Alloys to Nanocrystals. Amsterdam: Elsevier, 2006.
- [8]. Kainer, K.U. (editor), Magnesium alloys and technology, DMG, 2003, WILEY-VCH, ISBN 3-527-30256-5.
- [9]. Smith, W.F., Structure and properties of engineering alloys, second edition, 1993.
- [10] M.J. Starink, A.-M. Zahra, "β' and β precipitation in an Al-Mg alloy studied by DSC and TEM", Acta mater., 46 (1998) p.3381-3396.