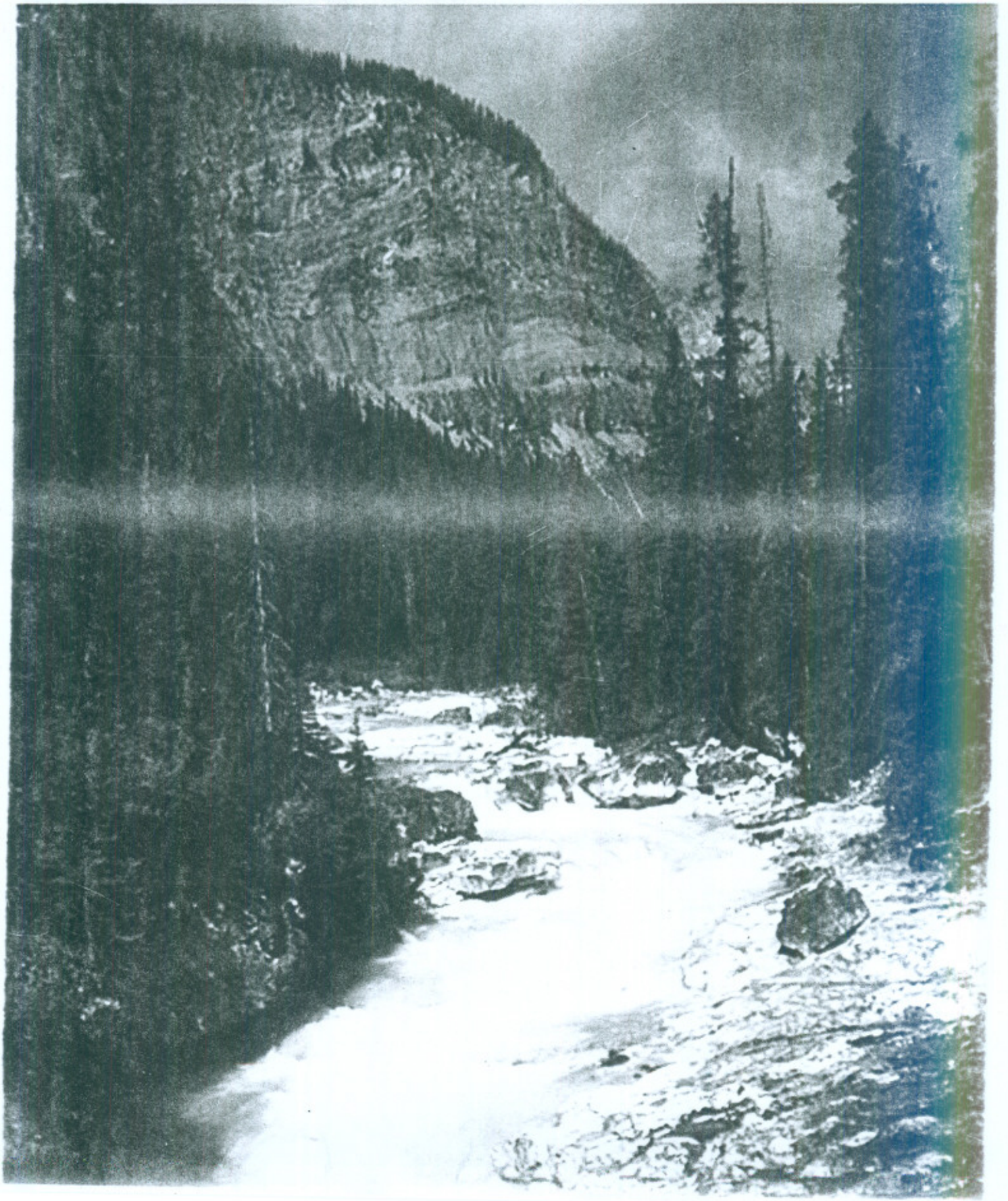
Engineering News

A Quarterly Journal of the Pakistan Engineering Congress

Vol: 42 July - September 2006 No: 10



PAKISTAN ENGINEERING CONGRESS
THE EXECUTIVE COUNCIL FOR THE 70TH SESSION

PRESIDENT

Engr. Rana Muhammad Saeed Ahmed Khan

VICE PRESIDENTS

1	Engr. Muhammad Siddiq Chattha	9	Engr. R. K. Anver
2	Engr. Muhammad Arif	10	Engr. Prof. Mian Zia-ud-Din
3	Engr. Ch. Ghulam Hussain	11	Engr. Dr. Izhar ul Haq
4	Engr. Ch. Muhammad Rashid Khan	12	Engr. Husnain Ahmad
5	Engr. Syed Akhtar Ali Shah	13	Engr. Syed Anwar-ul-Hasan
6	Engr. Syed Mansoob Ali Zadi	14	Engr. Faqir Ahmad Paracha
7	Engr. Ikram-ul-Haq	15	Engr. Abdur Raziq Khan
8	Engr. Dr. Bagh Ali Shahid		

OFFICE BEARERS

1	Engr. Syed Mansoob Ali Zaidi	. . .	*Secretary*
2	Engr. Shabir Ahmad Qureshi	. . .	*Joint Secretary*
3	Engr. Ch. Muhammad Shafiq	. . .	*Business Manager*
4	Engr. Zaffar Ullah Khan	. . .	*Publicity Secretary*
5	Engr. Ahmad Nadeem	. . .	*Treasurer*

EXECUTIVE COUNCIL MEMBERS

1	Engr. Akhtar Abbas Khawaja	19	Engr. Khalid Javed
2	Engr. Ch. Khuda Yar	20	Engr. Ahmad Nadeem
3	Engr. Muhammad Ibrahim Malik	21	Engr. Nayyer Saeed
4	Engr. Najam Waheed	22	Engr. Syed Nafasat Raza
5	Engr. Anwar Ahmad	23	Engr. Pir M. Jameel Shah
6	Engr. Naveed Alam	24	Engr. Malik Atta-ur-Rehman
7	Engr. Zaffar Ullah Khan	25	Engr. Capt. (R) M. Qadir Khan
8	Engr. Ch. Aftab Ahmad Khan	26	Engr. Muhammad Naeem Chughati
9	Engr. Tahir Anjum Qureshi	27	Engr. Shahid Ahmad
10	Engr. Liaqat Hussain	28	Engr. Syed Saleem Akhtar
11	Engr. Abdul Sattar Khan Lillah	29	Engr. Shehzad Jamil Sheikh
12	Engr. Rana Muhammad Ghous	30	Engr. M. S. Khan
13	Engr. M. M. Khan	31	Engr. Sabir Khan Saddozai
14	Engr. Sajjad Hussain Nasim	32	Engr. Iftikhar Ahmad
15	Engr. Ijaz Ahmad Cheema	33	Engr. Muhammad Saeed
16	Engr. Ali Waqas Ch.	34	Engr. Taufique Ahmad
17	Engr. Ch. Muhammad Shafiq	35	Engr. Syed Abdul Qadir Shah
18	Engr. Tariq Iqbal Mian		

47th YEAR OF PUBLICATION

Engineering News

A Quarterly Journal of the Pakistan Engineering Congress
Vol. 42 July - September 2006 No. 10

ON OTHER PAGES

IN THIS ISSUE

BOARD OF EDITORS

CHIEF EDITOR
Engr. Muhammad Ashiq Saleemi

EDITORS
Engr. Abdul Waheed Mir
Engr. Mian Iftikhar Ahmad
Engr. M. P. Aftab
Engr. Naveed Alam
Engr. Zubair Imran Khawaja

EDITORIAL

☆ Under-utilization of Engineering Professionals 3

NEWS

☆ Biofuels are promising but would require a major shift 4

TECHNICAL VIEWS

☆ Rain Water Harvesting to Control Desertification in Pakistan 9
-Muhammad Nawaz Bhutta

☆ Influence of Alloying Elements on the Hardenability of Steel 18
-Engr. Sana Rafiq and Engr. Javed Iqbal

☆ Densification of Steel through Hot-Sintering and the Resetting Hardness 27
-Dr. Liaqat Ali and Gul Hameed Awan

☆ Increase in Surface Hardness of SG Iron and High Carbon Steel by A Pack Chromizing Technique 34
-Rizwan Ahmad, M. A. Raza, A Salam and J. Ahmad

☆ Harnessing the Streams and Setting Management of Sustainable Water Resources Development 37
- I. B. Sheikh

☆ Mechanical Properties of Welded Duplex Stainless Steels 45
-M. Ajmal and A Nawaz

☆ TQM Philosophy based Pakistan National Quality Award 50
- Dr. Nawaz Khan

PUBLISHED BY
Pakistan Engineering Congress
Ph: 5784237-5784238 Fax: 5784236

FOR MEMBERS ONLY

Pakistan Engineering Congress is a prestigious professional body established in 1912 dedicated, interalia to technical advancement of Science & Engineering in the country.

- ALL COMMUNICATIONS SHOULD BE ADDRESSED TO THE CHIEF EDITOR, ENGINEERING NEWS PEC BUILDING, LIBERTY MARKET, GULBERG-III, LAHORE.
- FREE TO MEMBERS OF PAKISTAN ENGINEERING CONGRESS.
  ANY CHANGE OF ADDRESS SHOULD BE PROMPTLY INTIMATED GIVING OLD, AS WELL AS, NEW ADDRESS ALONGWITH MEMBERSHIP NUMBER.
- CONTRIBUTION TO THIS JOURNAL IN THE FORM OF ARTICLES, NEWS ABOUT ENGINEERING WORKS, NEWS ABOUT ENGINEERS, PHOTOGRAPHS AND TECHNICAL DATA ETC. ARE CORDIALLY INVITED.
- REPRINTS FROM THIS JOURNAL BE MADE ON THE CONDITION THAT REFERENCE IS GIVEN TO THE ENGINEERING NEWS, ITS VOL. NO. AND THE AUTHOR.
- PAKISTAN ENGINEERING CONGRESS IS NOT RESPONSIBLE FOR ANY STATEMENTS MADE OR OPINIONS EXPRESSED IN THIS JOURNAL.

Editorial

Under-utilization of Engineering Professionals

Engineering professional within the government jurisdictional activities are really not encouraged to touch the higher echelons of administration. Before partition they were considered to be very important actors in the national development and respected accordingly. Their status has been on the decline since and to the present stage has been reduced to subservient position. There may be umpteen reasons but that should not reflect only in their progress as the reason, whatever, are common to all classes of civil service. Presently their appointments do not go beyond BPS-20 as Chief Engineers or equivalent. However, there was a brief period from 1970 to 1980 when they were promoted as Secretaries to the Government, particularly in the Punjab Province It is high time that government, give consideration to improving their professional and administrative skills to bring them at par with superior services in Pakistan. It is not denying the fact that some of the professionals at present are serving as federal secretaries, equivalent or even higher but that is only an exception but not a rule.

Being dejected or finding environment not conducive to their career building, professional progress or personal well being, they opt to migrate or work abroad that results in brain drain. Pakistan can no more afford to loose such professionals in order to attain better standards of development. All over the world the professionals lead their departments in research, development and application and why not in Pakistan.

For achieving good efficiency in development progress one or two issues are very important and of urgent nature i.e. frequent transfers, indiscriminate suspensions and prolonged periods prior to promotion. Training within and or out side the country is very necessary to attain state of the art skills. For some years US AID had played a vital role in financing the training abroad. Government may revitalize such programs or provide funds from its own resources. A large number of training facilities, however, goes un-utilized because of lack of readiness and one factor is non-willingness of persons to proceed on training for selfish reasons. In fact introduction of examination to all levels of promotion will be necessary for not only persuading the individuals to benefit from training but also help sifting the quality professionals to higher grades.

Pakistan Engineering Congress, Pakistan Engineering Council and Governments in particulars must have some "Think Tanks" working continuously on improving the professional set-up in the country. It will pay back. Hopefully, newly formed National Commission for Government Reforms will give due consideration and importance to the engineering professional's role in the efficient services delivery to the masses.

News

BIOFUELS ARE PROMISING BUT WOULD REQUIRE A MAJOR SHIFT

Complied by

Mian Iftikhar Ahmad*

Biofuel or biomass energy are formal names for fuel created from stuff that can be grown. The most common forms of biofuel are ethanol (derived from sugarcane or corn) and biodiesel (fuel made from natural, renewable sources such as vegetable oils). Creative alternative energy folks have also used everything from livestock droppings to heather, and look to perennial crops like switchgrass and poplar trees as low maintenance sources. Just imagine a society fueled with clean, renewable, locally grown fuel.

In addition to providing a renewable source of energy for our transportation needs, and thus reducing greenhouse gases and dependence on foreign oil, biofuels could provide tens of millions of dollars of new income for farmers and rural communities.

Biodiesel – Overview

Biodiesel is an alternative fuel used in diesel engines. Biodiesel, in its pure form, is not made from petroleum; instead, all or part of it is derived from plant oils or animal fats. In the United States, most commercial biodiesel is made from soybean oil, in Europe, from rapeseed (canola) oil and in India from Jatropha oil. Biodiesel can be made from virgin oil, or from used cooking oil recycled from restaurants and food processing operations. **In Pakistan, we can grow and produce Biodiesel from Jatropha plant and from Switchgrass.**

As a motor fuel, biodiesel has numerous advantages:

Biodiesel Benefits

- Biodiesel runs in any conventional, unmodified diesel engine
- Biodiesel can be used alone or mixed in various percentages with petroleum diesel
- Biodiesel can be stored and transported anywhere that petroleum diesel is stored (with little or no damage in the event of a spill). It's biodegradable and non-toxic.
- Engines running biodiesel have similar fuel mileage to engines on diesel fuel
- Biodiesel is a renewable fuel; to make more, we just grow more of the crop needed
- Biodiesel can be produced domestically, displacing imported petroleum
- Biodiesel reduces the amount of pollution emitted from diesel engines.

On the negative side, biodiesel produces more nitrogen oxide, which contributes to smog. In addition, pure biodiesel does not flow as well as petroleum diesel in cold temperatures, so it could result in increased engine clogs.

Biodiesel should not be confused with straight vegetable oil, which is untreated oil that some people use as fuel in their modified diesel cars. Biodiesel is a more standardized product that can be used in most diesel engines without any modifications. In the United States, commercial biodiesel is defined by ASTM D6751 specifications, which outline specific properties of the fuel, such as viscosity and sulfur content. Rules like the ASTM standard

---

*Water, Sanitation and Environmental Engineer

ensure that certified biodiesel burns properly in modern diesel engines. But like conventional diesel fuel, **biodiesel can only be used in diesel engines**; today's hybrids with their spark-ignition, gasoline engines cannot burn biodiesel.

Biodiesel can be used in its pure form, which is called B100 (100 percent biodiesel), or can be blended in any proportion with conventional diesel fuel. Common blends include B20 (20 percent biodiesel and 80 percent conventional diesel), and B5 (5 percent biodiesel and 95 percent conventional diesel).

Bio-logistics

Expense: In the beginning, the commercial biodiesel may tend to be more expensive than conventional diesel. The price of biodiesel may get closer to the price of conventional diesel and, in some cases, cheaper when it gains popularity and is produced commercially on a large scale.

Convenience: In the beginning, finding biodiesel can be difficult. While conventional diesel is sold at roughly all the retail locations in Pakistan, for example, biodiesel may be offered in just few sites. If you live close to one of those sites, then you're in business. Otherwise, it's a challenge. But it will be available on all retail outlets sooner or later.

The inconvenience may not be such a big issue—if you're comfortable with switching back and forth from petroleum diesel and biodiesel. If you normally run B20, but go on a trip and can only find standard diesel, fill in right away. It doesn't matter how much of either fuel is left in your tank. Splash blending is not a problem.

Do It Yourself OPEC

For many biodiesel users, the issues of pump price and location are irrelevant since these users make their biodiesel rather than buy it.

Unlike any other fuel for modern engines, biodiesel can be made at home without investing heavily in special equipment or earning a degree in chemistry. Many who make their own biodiesel use waste cooking oil as the base fuel, and restaurants are often happy to provide it to them free of charge. Other components for the reaction must be purchased, and time is required to master the production process. Once a user is experienced in making biodiesel, the per-gallon cost can be extremely low. Perhaps even more satisfying than the low cost is the knowledge that using biodiesel puts nothing in the coffers of major oil companies or major oil-producing nations and, in many cases, reuses oil that would otherwise be discarded.

Interestingly, biodiesel users note that exhaust fumes from their engines often reflect the origin of their waste cooking oil—anything from donuts to wontons.

Greasing the Wheels of Progress

Many biodiesel proponents also claim that using biodiesel can lead to less wear on engines and greater engine life. Studies confirm that blends that contain small amounts of biodiesel (up to 5 percent) have greater lubricity: they more effectively lubricate components of the fuel system, such as injectors and fuel pumps. Particularly when added to ultra-low-sulfur diesel fuel, biodiesel can play an important role in maintaining lubricity and extending the life of engine components. Ultimately, the decision to use B100 and other biodiesel blends is a personal choice. If you have a diesel vehicle, like the idea of making your own fuel (or live

close to a biodiesel source), and are concerned about global warming, biodiesel is a good choice.

Ethanol – Overview

Ethanol can be mass-produced by fermentation of sugar or by hydration of ethylene from petroleum and other sources. Current interest in ethanol lies in production derived from crops (**bio-ethanol**), since it is a sustainable energy resource that offers environmental and long-term economic advantages over fossil fuels, like gasoline or diesel. It is readily obtained from the starch or sugar in a wide variety of crops. Ethanol fuel production depends on availability of land area, soil, water, and sunlight.

Ethanol fuel is an alternative to gasoline. It can be combined with gasoline in any concentration up to pure ethanol (E100). **Anhydrous ethanol**, that is, ethanol without water, can be blended with gasoline in varying quantities to reduce the consumption of petroleum fuels, as well as to reduce air pollution. In the US, tolerance of ethanol depends on the individual vehicle. In Brazil, ethanol-powered and flexible-fuel vehicles are capable of running on **hydrated ethanol**, a distilled mixture of ethanol and water. In addition, most flexible-fuel vehicles can run on mixtures of hydrated ethanol, anhydrous ethanol and gasoline, as long as there's at least 20% of ethanol. A few flexible-fuel systems, like the Hi-Flex, used by some vehicles can also run with pure gasoline.

Ethanol is increasingly used as an oxygenate additive for standard gasoline, as a replacement for methyl t-butyl ether (MTBE), the latter chemical being responsible for considerable groundwater and soil contamination. Ethanol can also be used to power fuel cells and to produce biodiesel.

In 2004, around 42 billion liters of ethanol were produced in the world, most of it being for use in cars. Brazil produced around 16,4 billion liters and used 2,7 million hectares of land area for this production, or 4,5% of Brazilian land area used for crop production in 2005 Around 12,4 billion liters were produced as fuel to ethanol-powered vehicles in domestic market.

Ethanol is, by far, mostly used to power cars, but it may be used to power other vehicles, like farm tractors and airplanes. Current ethanol engines are modified gasoline engines and require few adjustments to operate reliably. Ethanol consumption is around 30% higher than that of gasoline, but higher compression rates allow for a little better power output. Flexible-fuel vehicles, however, are tuned to give the same output, with either gasoline or hydrated ethanol.

Ethanol fuel mixtures

Fuel system design must be compatible with the percent of ethanol permitted. All current (2006) production spark ignition vehicles in the United States are designed to be compatible with up to 10% ethanol. Every gasoline-powered vehicle in Brazil (since 1993) is designed to be compatible with up to 25% ethanol. Pure ethanol reacts with or dissolves certain rubber and plastic materials and must not be used in fuel systems that are not designed for it.

Pure ethanol has a much higher octane rating (116 AKI, 129 RON) than ordinary gasoline, allowing higher compression ratio and different spark timing for improved performance. To change a pure-gasoline-fueled car into a pure-ethanol-fueled car, larger carburetor jets (about 30-40% larger by area), or fuel injectors are needed. (Methanol requires an even larger increase in area, to roughly 50% larger.)

Engines using fuel with from 30% to 100% ethanol need a cold-starting system for reliable starting at temperatures below 13 °C (55 °F) and to meet EPA emissions standards.

In many countries cars are mandated to run on mixtures of ethanol. Brazil requires cars be suitable for a 25% ethanol blend, and has required various mixtures between 22% and 25% ethanol, as of October 2006 23% is required. The United States allows up to 10% blends, and some states require this (or a smaller amount) in all gasoline sold. Other countries have adopted their own requirements. Because of this requirement it is speculated that all cars can run blends up to about 30% (so that manufactures do not have to stock parts incompatible with ethanol next to parts compatible), but it is not known if this is true.

Beginning with the model year 1999, an increasing number of vehicles in the world are manufactured with engines which can run on any fuel from 0% ethanol up to 100% ethanol without modification. Many cars and light trucks (a class containing minivans, SUVs and pickup trucks) are designed to be flexible-fuel vehicles (also called *dual-fuel* vehicles). Their engine systems contain oxygen sensors in the exhaust that provide input to the engine control computer to adjust the fuel injection to achieve stochiometric (no residual fuel or free oxygen in the exhaust) air-to-fuel ratio for any fuel mix. The engine control computer also adjusts ignition timing to achieve maximum output without pre-ignition.

Environmental effects

Air pollution

Compared with conventional unleaded gasoline, ethanol is a particulate-free burning fuel source that combusts cleanly with oxygen to form carbon dioxide and water:

In considering the potential for pollution reduction with ethanol, however, it is equally important to consider the potential for environmental contamination stemming from the manufacture of ethanol. Ethanol plants release VOCs when fermented corn mash is dried for sale as a supplement for livestock feed. Devices known as thermal oxidizers or catalytic oxidizers can be attached to the plants to burn off the hazardous gases.

Effects of ethanol on agriculture

Environmentalists have objections to many modern farming practices, including some practices useful for making bioethanol more competitive ("factory farming"). If more third-world land were to be converted to agriculture to feed ethanol fuel demand, there is the possibility of trading today's automotive pollution for tomorrow's farm pollution.

There is some potential that through irresponsible farming methods some rainforest areas could be cleared to make land available for growing crops for commercial commodities such as palm oil for the generation of biodiesels.

Economics

As yields improve or different feedstocks are introduced, ethanol production may become more economically feasible. Currently, research on improving ethanol yields from each unit of corn is underway using biotechnology. By utilizing hybrids designed specifically with higher extractable starch levels, the energy balance is dramatically improved. Also, as long as oil prices remain high, the economical use of other feedstocks, such as cellulose, become viable. By-products such as straw or wood chips can be converted to ethanol. Fast growing species like switchgrass can be grown on land not suitable for other cash crops and yield high levels of ethanol per acre.

Ethanol Benefits

- Up to a 10 percent blend of ethanol is already covered under warranty of every auto manufacturer
- A blend with 85 percent ethanol burns in an extremely clean and complete manner
- E85 is already running on millions of so-called E85 flexible cars in the U.S. These cars, primarily used in corporate and government fleets, are manufactured by DaimlerChrysler, Ford, GM and Mercedes. Most of the E85 flexible cars are wagons and pick-ups.
- The biggest drawback with high-ethanol blends today is that they are not widely available.

Major Shift Required

A grow-your-own approach to fueling our cars and trucks sounds very enticing. A major shift to biofuels could put our farmers to work, greatly reduce greenhouse emissions, and free us from dependence on the oil producing countries. A shift to a biofuel infrastructure would not happen overnight. It would require a major shift in our collective political will.

This potential shift also raises serious concerns about land use, pesticide use, and genetically modified crops, as well as difficult economic questions about the net costs of using land for food production versus energy production.

Hybrid cars by definition use more than one source to power a car. As a result, hybrids are often referred to as a bridge technology between currently available technologies and promising future approaches, such as hydrogen fuel cells. As carmakers continue to improve gas and diesel engines, and experiment with hybridization, perhaps biofuels will be brought into the mix—but only if fossil oil becomes more scarce, more costly to produce and import, and even more obviously destructive to the environment.

www.autos.yahoo.com

RAIN WATER HARVESTING TO CONTROL DESERTIFICATION IN PAKISTAN

By

Muhammad Nawaz Bhutta*

ABSTRACT

Main reasons of desertification are drought, flooding, water and wind erosion, waterlogging and salinity, deforestation, live stock grazing pressure, loss of bio-diversity and socio-economic constraints. Rain over Indus Plain, encompassing an area of about 203,315 sq.km is primarily consumed by the plants. In the rest of the area, major part of rainwater goes waste either as surface evaporation or is carried to the sea without yielding any utility. Rainwater harvesting is though an old technology but is now getting importance at large scale in many developing countries to enhance the supply of water. In Pakistan, use of rainwater has ancient history. It is either directly '*Barani*' agriculture or carried by hill torrents through the construction of temporary diversion structures ('*Rod Kohi*'). A total of 550 structural interventions have been constructed in Pakistan to harvest rainfall. Balochistan has more than 450 structures while in Punjab, NWFP and Sindh nearly 100 delay action dams and dispersion structures have been constructed to conserve flows of hill torrents. The overall water conservation potential of hill torrents of four provinces and federal area is 12.8 MAF. This potential consists of 2.1 MAF in Federal areas, 2.1 MAF in Punjab, 4 MAF in NWFP, 0.6 in Sindh and 4 MAF in Balochistan. Although a large overall potential exists, yet the construction of control structures in such unpredictable and changing channels regimes is a difficult task. Adoption of flexible type of construction involving intensive use of stone gabions as training works, diversions and delay action dams has provided some management opportunities over the preceding decades. Based on the efficacy of these structures, there is a strong need for developing better and more reliable strategies to impart long life, lesser maintenance and more reliability to such strategies. In view of the anticipated constraints, it is estimated that over next 25 years some 3 MAF of water could be considered a reasonable water development potential for hill torrents. There is a dire need for research to develop improved techniques towards imparting greater permanency to structural interventions and effective management of hill torrents to control desertification in Pakistan.

1. INTRODUCTION

The causes of desertification can be counted as drought, flooding, water and wind erosion, waterlogging and salinity, deforestation, live stock grazing pressure, loss of bio-diversity and socio-economic constraints. Rainwater harvesting can reduce ill effects of drought, floods and water erosion. Rain over Indus Plain, encompassing an area of 203,315 sq.km is primarily consumed by the plants. In the rest of the area, major part of rainwater goes waste as surface evaporation or wastefully carried to the sea. Rainwater harvesting is an old technology which is now getting importance at large scale in many developing countries to enhance the supply of water. In Pakistan, use of rainwater has ancient history. It is either used directly for *'Barani'* agriculture or carried by hill torrents through the construction of temporary diversion structures (*Rod Kohi*). Rainwater harvesting is an ancient practice on which people in arid zones have tried to survive at subsistence level for ages. The Bedouins of the Middle East used to sow grain on terraces they constructed in dry riverbeds or *Wadis*. These nomads would move through the desert and return to their terraced *Wadis* after the rainy season. In those wadis where rainfall had produced flow, the runoff water infiltrated in

*Director General IWASRI, WAPDA Near Muhammad Pura Village P.O. Thoker Niazbeg, Lahore.

the terraces on which wheat could be grown. The basic knowledge of these desert dwellers enabled them to understand the characteristics of desert rainfall: distribution was erratic in space and time and total annual rainfall was low. Nobody knew that where, when and how much it would rain. To be on the safe side, they would sow grains in many Wadis to harvest from a crop from a few *Wadis*, months after the rainy season.

Water harvesting has a direct and strong relation with erosion control. In both technologies, water is forced to infiltrate in the soil so that surface runoff is limited in depth, velocity and erosive power.

Although the practice of rainwater harvesting is old, renewed interest has led to new definitions, the first of which was introduced in the 1950s by Geddes in Australia: 'the collection and storage of any farm waters, either runoff or creek flow, for irrigation use'. All practices in water harvesting have three characteristics in common. First, they apply to arid and semi-arid zones where runoff has an intermittent character; second, they all depend on local water such as surface runoff and creek flow; third, they are relatively small-scale operations in terms of catchment area, storage volume and capital investment. A practical and comprehensive definition of rainwater harvesting is 'a method of inducing, collecting, storing and conserving local surface runoff for agriculture in arid and semi-arid regions'.

In arid zones where rainfall is too low for agriculture, water harvesting can be used to concentrate runoff water on a limited area, which then receives enough water for cultivation. Figure 1 shows a small catchment with basin in which a tree is planted. This applies to areas with average annual rainfall of roughly 250 millimeters. The ratio of catchment or runoff area (A) to cultivated or basin area (B) typically varies between 1 and 100. In true deserts with annual rainfall below 100 millimeters the ratio A/B would become larger than 100, meaning runoff from a catchment of 100 hectares would allow cultivation on one hectare only. Although this was acceptable to the primitive nomads but for modern application, the practice would become too extensive. In sub-humid zones with annual rainfall above 500 millimeters, the A/B ratio would become small, indicating no need for water harvesting (Boers, 2004).

The following water balance equations apply in units of depth.

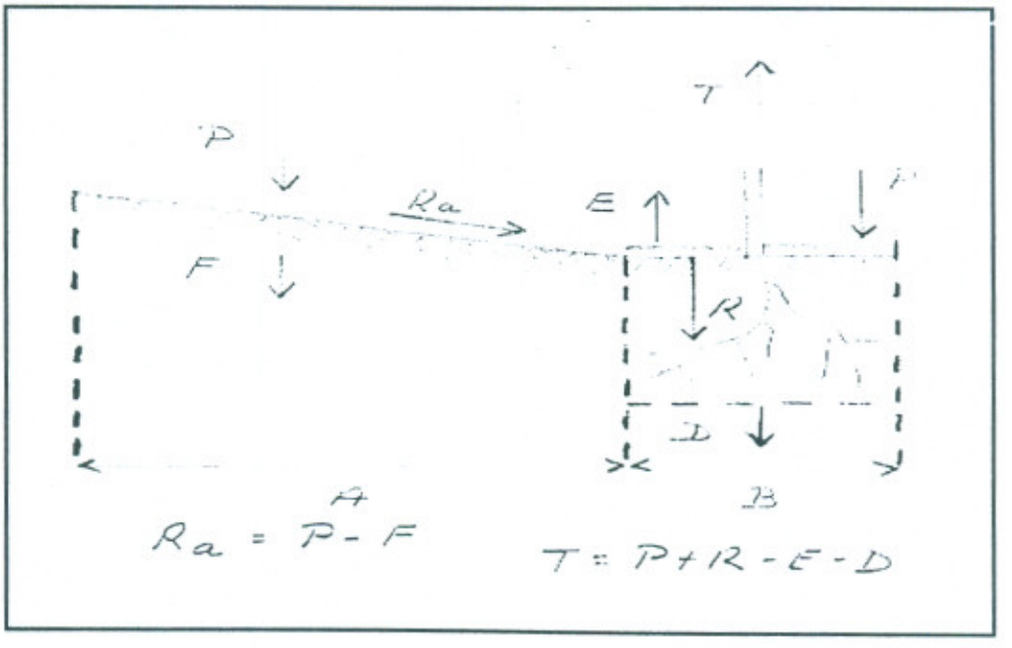


Figure 1. Small water harvesting system with runoff area A, basin area B and rootzone.

For the runoff area (A) $P = Ra + F$ (1)

Where P is rainfall depth, Ra is runoff and F is infiltration loss on runoff area (mm).

For the basin area (B) $P + R = T + E + D + dS$ (2)

R is runoff depth on basin, T is transpiration by tree, E is evaporation loss from basin, D is deep drainage below rootzone of tree and dS is increase in water stored in rootzone (mm).

In water harvesting, it is tried to induce runoff and reduce the infiltration losses during the runoff process, so that total runoff depth becomes maximum. Once the runoff water is collected in the basin, it is tried to reduce evaporation and deep drainage losses in the basin, so that the beneficial use by transpiration and growth becomes maximum. Different layout patterns have been used for runoff agriculture in the traditional terraced *Wadis* and desert strip farming to micro-catchments with trees as given in Figure 1.

2. OBJECTIVES

Main objectives of the study are to:

i) Review the past experiences of rainwater harvesting;
ii) Identify the potential of rainwater harvesting in Pakistan; and
iii) Prepare recommendations for economical and reliable strategies.

3. RAIN WATER HARVESTING PRACTICES AND TECHNIQUES

Water harvesting comprises of four processes, each of which has its own characteristics: (a) inducing runoff, (b) collecting runoff, (c) storing runoff water and (d) conserving stored water. In practice, most efforts have been directed towards (a) and (b). Many schemes have failed because (c) and (d) were neglected. Inducing runoff starts with the selection of the proper soil, which will develop a surface crust for limited infiltration and better runoff production. Many surface treatments have been tried starting with removal of vegetation and rocks to spraying with asfalt and tar or application of parafin wax and salt to seal the surface. Some of these treatments are costly and some are risky, such as use of salt. For efficient runoff collection, proper slope and layout pattern is a must. For storing collected runoff water in the soil profile, cultivation of topsoil is important to enhance infiltration, limiting evaporation losses. Available volume of storage depends on effective porosity of the soil and rooting depth, for which selection of the proper type of tree is essential. Large storage volume will limit the deep drainage losses. Conservation of stored water can be improved by cultivating or mulching the topsoil so that evaporation losses are reduced.

In arid and semi-arid regions, it is necessary to store the maximum amount of rainwater during the wet season for use at later time, especially for agricultural and domestic water supply. Techniques of rainfall harvesting can be categorized as non-structural and structural. Non-structural techniques include:

i) Planning cropping patterns consistent with rainfall patterns;
ii) Select high value crops for maximum income;
iii) Adjust sowing time according to probable rainfall so that drought sensitive stages of crop do not synchronize with the periods of inadequate rainfall;
iv) Timing of other farm operations such as tillage, fertilizer application, applying insecticides and herbicides etc. in relation to rainfall probability periods;
v) Follow mixed cropping of shallow and deep rooted crops for full exploitation of stored soil moisture;

vi) Adopting inter-cropping practices since water needed for a single and for several crops together is more or less the same but total production can be much higher in the later system than the former; and
vii) Improving weather forecasting techniques and using predictions in planning farm operations.

Generally the structures constructed for controlling and harvesting rainfall include:

i) Dispersion structures;
ii) Diversion embankments;
iii) Delay action dams;
iv) Storage dams;
v) Flood walls;
vi) Flood diversion channels; and
vii) Concreting rainfall areas and diverting flows to small ponds.

4. EXPERIENCE IN WATER HARVESTING

4.1 International Experience

Ancient practices in water harvesting can be found in the city of Ur in Iraq. More modern approaches have been developed in research programs in Iran, where slopes were covered with asphalt to increase runoff. In Egypt, research is ongoing in the coastal area where rainfall is 200 millimeters, but soils are sandy. In the US, most research has been done in Arizona, where all kinds of surface treatments were tried out, such as parafin wax, salt, plastic and rubber linings. Experiments were also conducted in reduction of reservoir evaporation by rafts, oil films and compartmented reservoir designs. In 1974, an international workshop was organized in Arizona to define the state of the art. One conclusion was that water harvesting is not feasible in the American economy i.e. cost was higher than returns. In arid northeastern Brazil, water harvesting trials have been conducted. In Australia, water harvesting was revitalized to fill small dams with farm water. In Asia, loess soils in the dry zones of China are very suitable for water harvesting and could be combined with the erosion control programs. In India, extensive research was conducted at Jodhpur in the Bikaner district. In Africa, many water harvesting schemes have been set up at village level, particularly in the Sahel zone and in the desert zones of southern Africa, such as Kalahari Desert of Botswana. In Europe, growers of flowers and vegetables in the western part of the Netherlands apply the principles of water harvesting below sea level. Runoff from greenhouses is collected and stored in lined basins for trickle irrigation systems and hydro-cultures.

4.2 Pakistan Experience

Major areas traversed by hill torrents constitute nearly 65% of total area of Pakistan and encompass entire Balochistan, with three component basins, namely, Mekran Coastal Basin, Indus Basin and Kharan Closed Desert Basin. The other major hill torrents areas include Derajat Plains of D G Khan and D I Khan; Pothowar Plateau, Kurram and Kohat Basin, Kabul and Swat River basins, Hazara and Kohistan Basin, Khirthar, Karachi and Petaro Hill Torrents, Federally Administered Tribal Areas (FATA), Federally Administered Northern Areas (FANA) and Azad Jammu & Kashmir.

4.2.1 Structural Interventions

Rod Kohi Irrigation is the traditional practice of rainwater harvesting in the piedmont plains of Suleman Range since beginning of 20th century. Initially the system was very efficient. Due to poor maintenance the dispersion structures are not functioning properly at many places. The

present condition of Rod Kohi system warrants an effective management of the flood flows of hill torrents.

Many small and delay action dams have shown limited life due to siltation and seepage. However these are very useful for groundwater recharge. Unfortunately traditional in-efficient irrigation methods are used for irrigation in these water scarce sites also.

In Pakistan a total of some 550 structural interventions have been constructed to harvest rainfall. Balochistan has more than 450 structures while in Punjab, NWFP and Sindh 100 delay action dams, dispersion structures, etc have been constructed to conserve flow from hill torrents.

4.2.2 Sailaba Farming Systems in Balochistan

Sailaba farming is a traditional system of watering fields through harnessing, diversion and control of flood water, which has been practiced since 3000 years BC. In Balochistan province only the potential area under Sailaba farming with in the existing framework is around 41 percent of the total cultivated area. According to NESPAK 1998, there is potential to further increase the Sailaba area to 4.68 million ha within the existing distribution of water. PARC concluded that with the introduction of tubewell technology, the Sailaba system was neglected and thus it has deteriorated tremendously. The beauty of Balochistan Sailaba system is that the area outside Kachi and Lasbela is small and easy to manage – highlands of Balochistan (PARC 2001).

4.2.3 Khushaba Farming Systems in Balochistan

Khushaba farming is a traditional system of supplementing incident rainfall with runoff from adjacent fields or catchments. In Balochistan potential area under Khushaba Farming within the existing framework is around 0.26 million ha, representing 12 percent of the total cultivated area. The technology support was never provided to farmers because water management in Khushaba areas is no-body business, except the research institutions who have very little resources. The system has been deteriorated to the extent that a major rehabilitation is needed. It should be considered as an integral part of the main water management strategy.

The research efforts by Arid Zone Research Centre (ARZC) have been concentrated to introduce runoff and run-on systems, which could not be adopted by farmers. The basic reason was that the scientist neither tried to understand the indigenous Khushaba systems nor made any effort to improve these systems. Introduction of new imported technology is difficult and there is considerable time lag for adoption of these technologies. AZRC is the only centre in Balochistan having mandate, trained manpower and programme for research related to Khushaba farming. But there is a need to re-orient the research programme in collaboration with agriculture and forestry departments to initiate Action Research responsive to the needs of the clients (line departments and farmers).

4.2.4 PCRWR Study

In Pakistan, PCRWR is active in launching water harvesting schemes in Cholistan. A study titled "Optimization of Rainwater Storage Reservoir in Cholistan" was conducted by PCRWR (PCRWR, 2002). Following were the main conclusions and recommendations:

i) Seepage losses from reservoirs are huge and difficult to exactly quantify;
ii) Maximum efficiency of reservoir for minimum losses is for ponds with rectangular cross-section.
iii) Optimum size of storage is 4 million gallons with 25 feet depth;

iv) The estimated cost of water is Rs.0.18 per gallon.
v) Seepage can be reduced by 1 mm thick plastic sheet under clay cover.

5. GUIDELINES FOR RAINWATER HARVESTING

5.1 Basic Requirements for Water Harvesting

There are a few requirements to consider in planning, design and application of water harvesting schemes. Table 1 gives a summary of requirements.

Tabe 1. Conditions, requirements and recommendations for water harvesting

Conditions & applications	Requirements & recommendation
1.Climate	Arid to semi-arid
Annual Rainfall	100 to 500 mm
2.Topography and soil	Desert plain with loamy soils
Slope	2 to 5 percent
Soils	Loess surface crust and water holding capacity
3.Runoff Area	
Drinking water	Corrugated tin roof feeding tank
Cattle water	Natural catchment feeding reservoir
Agriculture	Runoff area feeding basin area
4.Storage	
Drinking water	Closed concrete tank
Cattle water	Lined reservoir or unlined pond
Agriculture	Rootzone below basin area or in aquifer

These conditions and recommendations are briefly discussed in the following paragraphs.

Water harvesting cannot be more reliable than the weather. In times of drought, there is no rainwater to harvest. But during rainy seasons, water harvesting can be attempted to store water, which is then available during dry seasons or in dry years. Water harvesting has been practiced successfully in areas having average annual rainfall of 250 millimeters, say in the range from 100 millimeters to 500 millimeters; these are arid and semi-arid zones (Table 1).

When selecting an area for water harvesting schemes, some slope is needed for water to flow. However, too steep slopes give high flow velocities with erosion problems such as gully formation and too much sediment in the runoff water. A slope of two to five percent is usually enough. If the area slope is less than two percent, then too much water is lost in depression storage. Slopes between 5 and 10 percent are on the high side, while areas sloping more than 10 percent are usually unfit for agriculture.

When using water harvesting for agriculture, it is important to select an area with proper soil type. Basically, runoff area and basin area have contradictory requirements. On the runoff area, we need minimum infiltration and maximum runoff. In the basin area, we need rapid infiltration to reduce evaporation losses and maximum water holding capacity to reduce deep drainage losses. With the proper treatment, loamy wind blown loess soils can meet both requirements. If the soil is too sandy, runoff cannot be collected efficiently and deep drainage losses will occur. On the other hand, clay soils will develop cracks when dry, which does not produce good runoff and infiltration in the basin may be slow.

Depending on the purpose for which water is being harvested and local conditions, mode of storage is selected. For example if runoff from sloping corrugated tin roofs is collected for drinking water, storage in a closed water tank is the best. If surface runoff from a natural

catchment is collected, then water may be stored in an open reservoir, like the natural depressions or tobas in Cholistan Desert. Pakistan Council for Research in Water Resources (PCRWR) has constructed concrete storage reservoirs for this purpose in Cholistan. If water is being harvested for agriculture or forestry then shallow storage as soil water in the rootzone, is the cheapest method. If water harvesting is applied to redress a regional water balance, as with delay-action dams in Balochistan, then deep storage as groundwater is the best.

If harvested water is being used for agriculture then volume of storage depends on depth of rootzone. Crops or trees cannot reach soilwater stored in the profile underneath the rootzone. So a deep root system is a must if water harvesting is used for agriculture. That is why trees do better than crops. In case there is a rainy season followed by a dry growing season, then rootzone is filled up during the rainy season and depleted during the growing season. Rootzone storage is then essential to carry over the stored soilwater from rainy season to growing season. During the dry season, the trees must survive on the soilwater only, without any additional rainfall. Moreover, in the arid zones drought years are a natural phenomenon and sure to come. It is essential to select trees that can survive drought cycles and can restart growth when rainfall returns. A crop with a rooting depth of 50 centi meters will have only 50 millimeters of water available for growth during the dry season. A tree with five meters deep roots can take up 500 millimeters of soilwater during the dry season. In addition, some trees like Eucalyptus develop a very deep root system that can tap groundwater from deeper depths, which increases chance of survival during drought cycles.

Since drought years belong to the arid zone characteristics, it is important not to be dependent on water harvesting only. In case a village community has developed a water harvesting scheme and sees their efforts go waste during a drought cycle, this will shatter their confidence in the method. Therefore, it is important to have an alternative source of water for emergency. If local conditions are favorable, then a tubewell is the cheapest 'spare tire'. Any deep drainage loss would recharge the groundwater and keep the spare tire in good shape. A surface reservoir could also help, but it is more expensive and its storage is more limited than storage in an aquifer. For cattle water a reservoir may do, but evaporation losses would be a disadvantage. For subsistence agriculture a reservoir will not be a practical solution. For any water harvesting scheme where a cash crop would be tried, reservoir storage combined with trickle irrigation would be an option.

When developing concrete plans for funding water harvesting schemes, the following options may be considered. (a) Schemes to collect drinking water from corrugated tin roofs and storage of water in tanks. Storage tanks must be closed to avoid evaporation, pollution and mosquito breeding. (b) Schemes to harvest water for cattle. This water may be harvested from natural catchments and stored in open reservoirs or ponds, where cattle can reach it. Ideally, the reservoir is concrete lined. The low-cost alternative is an unlined pond. In this case, it is important to have the proper soil conditions with zero percolation. (c) Schemes to harvest water for agriculture. Storage will be soilwater in the rootzone. Most promising schemes are for trees, either fruit trees, timber, windbreaks or shelterbelts to protect farmland from wind erosion. (d) Advanced water harvesting schemes with surface storage or aquifer storage and village garden with vegetables on trickle irrigation. In all schemes, tubewell as spare tire is important.

5.2 Community Participation in Water Harvesting

The basic characteristics of water harvesting which make it a practice ideally suited for self-help schemes in rural communities are that this is simple, low-cost and environmental-friendly technology. Since water harvesting develops in arid zones, the local population feels attracted to it and can adapt it to their local needs on sustainable basis. Some outside

assistance is needed in the form of expert advice, so that the people can take advantage of experiences of rainwater harvesting of similar areas. For making small catchments and basins, manual labor can be used and women and children can help.

When considering success stories in community self-help schemes, China is probably world champion in erosion control by checkerboard designs in Gobi and other deserts. In Africa also, there are success stories in water harvesting village schemes, either for drinking water or for trees. Pakistan also has its success stories in the arid zones. However, most efforts are directed towards inducing and collecting runoff water, but if this water cannot be stored and conserved the scheme cannot succeed. If water is stored in a sandy profile or if gravel layers of former river beds are present, then water holding capacity is too limited for trees to survive. If catchment design is too small, then runoff volume is simply too low to satisfy water requirements for transpiration. It is understandable that water harvesting is being considered when water is scarce during drought years.

6. IDENTIFIED POTENTIAL

Average rainfall for the period 1960 to 2000 is given in Table 2. The overall potential of hill torrents in Pakistan is given In Table 3.

Table 2. Average Rainfall from 1960 to 2000 (mm)

Period	Pakistan	NWFP	Punjab	Sindh	Balochistan
Annual	291	577	381	165	159
Apr-Sep	190	337	290	145	82
Oct-Mar	101	240	90	19	77
Jul-Sep	138	203	231	130	60

Source: (GOP, 2002)

Table 3. Hill Torrents Potential

Provinces/ Areas	Identified Land Potential (000 ac)	No of Conservation Sites Identified	Total Potential (MAF)	Existing Uses (MAF)	Balance Potential (MAF)
Federal Areas	674	383	2.8	0.7	2.1
Punjab	4309	211	2.7	0.6	2.1
NWFP	1092	417	4.9	0.9	4.0
Sindh	4495	33	0.7	0.1	0.6
Balochistan	11517	423	7.0	3.0	4.0
Pakistan total	22087	1204	18.1	5.3	12.8

Source : (GOP, 2002)

Although a large overall potential exists, yet the construction of control structures in such un-predictable and changing channel regimes, is difficult task. Adoption of flexible type of construction involving intensive use of stone gabions as training works, diversion and delay action dams has provided some management opportunities over the preceding decades. Based on experience on the efficacy of these structures, there is dire need of developing better and more reliable strategies to impart longer life, lesser maintenance and more reliability to such strategies.

7. CONCLUSIONS

i) Under the prevailing circumstances and in view of many constraints, it is estimated that over the ensuing 25 years or so some 3 MAF of water could be considered a reasonable development potential of hill torrents. Meanwhile there is an urgent need for research to develop improved techniques towards imparting greater permanency to structural interventions and effective management of hill torrents in Pakistan.

ii) water harvesting must be practiced in wet years to build up storage for dry years. An alternative source of water to complement water harvesting is important. Self-help schemes are excellent for practicing water harvesting but proper guidance of the community is essential. Involvement of the community in applied research with field trials followed by planning and design is the best way to achieve results. Using water harvesting, offers good opportunities for an integrated approach with community participation and integration of rainfall, runoff, soil water and groundwater combined with erosion control. Experience indicates that mini-dams are more successful than handpumps and tubewells.

iii) Water harvesting offers good opportunities for Pakistan to involve village communities in low-cost self-help schemes for drinking water, cattle water or agriculture. The technology originates from the arid zones, is straight-forward, cost-effective, small-scale, environmental-friendly and attractive for rural populations. The first constraint is in the erratic low rainfall where water harvesting should be done in wet years to build up storage for dry years. The second constraint is in suitable soil conditions, which should generate runoff and have good water holding capacity. An alternative source of water such as a tubewell is important.

8. RECOMMENDATIONS

Based on the discussion in the paper, following recommendation are made:

i) Higher priority should be given to low cost and small scale conservation structures for rainwater harvesting;
ii) Adequate follow up should be done for completed schemes;
iii) Detailed feasibility study should be done before construction of mini dams;
iv) Funds should be allocated for dissemination of research findings and village experience;
v) Rural population should be trained in developed technologies;
vi) Rainwater harvesting scheme should have on-site rain gauge and evaporation pan; and
vii) Developments should be linked with research.

9. REFERENCES

Boers Theo. M. 2004. Rainwater Harvesting in Arid Zones. International Symposium on Community Based Approaches for Integrated Water Resource Management. UNDP, Islamabad.

GOP 2002. National Water Policy Volume II: Water Resources of Pakistan, Availability and Requirement.

PARC 2001. Evaluation Report of the Project entitled "Rod-Kohi System Development and Management in Pakistan". Pakistan Agricultural Research Council, Islamabad.

NESPAK 1998. Master Feasibility Study of Management of Hill Torrents of Pakistan – Balochistan Province. National Engineering Services of Pakistan.

PCRWR 2002. Final Report Research Study on Optimization of Rainwater Storage Reservoirs in Cholistan December 2002.

INFLUENCE OF ALLOYING ELEMENTS ON THE HARDENABILITY OF STEELS

By

Engr. Sana Rafiq* and Engr Javed Iqbal**

ABSTRACT

Hardenability is very important characteristic of steels, as it determines the depth to which given steel can be hardened through drastic quenching. Steels with high hardenability are needed for a wide range of structural applications, as well as cutting tools. A number of experiments have been performed to get data about the hardenability of 1040, 4140 and 8640 steels through microstructural analysis as well as hardness profiles. Since these steels have different alloying elements put in them, the influence of these elements on the hardenability have been discussed.

INTRODUCTION

This ability of steel to be hardened to a specified depth is called hardenability. The hardenability of steel is governed almost entirely by the chemical composition, the austenitizing temperature and the austenite grain size at the moment of quenching[1]. Such factors as time at the austenitizing temperature and prior microstructure are sometimes very important variables when determining the basic hardenability of a specific steel composition. The most economical way to increase the hardenability of plain carbon steel is to change the manganese content, from 0.60-1.40 wt %, giving a substantial improvement in hardenability. Chromium and molybdenum are also very effective, and amongst the cheaper alloying additions per unit of increased hardenability[2,3].

Maximum hardness in steels is obtained by producing a fully martensitic structure. This can be done by austenitizing the steel and then quenching it. During the austenitizing treatment all of the carbides dissolve and the ferrite transforms into austenite. Quenching causes the austenite to transform via a shear mechanism into martensite. This transformation is so fast that there is no time for carbon to diffuse out of the martensite grains or to form carbide phases[4,5]. The main object of present research was to study the effect of alloying elements on the hardenability response of these steels.

EXPERIMANTAL WORK

The chemical composition of the different materials used during present work is given in Table1,was determined by spectrometer. The Jominy test samples were prepared by using standard techniques. As the austenitizing was carried out at high temperature and probability of decarburization was always on card, to overcome this problem some of the samples were copper plated before the heat treatment was carried out. These samples were austenitised at 870°C - 925°C for 30 minutes in muffle furnace. Then quickly transferred to the jominy end quench apparatus, where they are held vertically for 15 minutes and sprayed by a controlled flow of water adjusted to about 2.5 inch high onto one end of the samples. The hardness is measured by Rockwell hardness tester at intervals of 1/16 inches up to 1 inch distance from

*Lecturer ** Professor in Department of Metallurgical & Materials Engineering, University of Engineering and Technology Lahore, Pakistan.

the quench end and 1/8 inches up to 2 inches, using C scale. For metallographic examination samples were prepared by conventional techniques. Metallographic study was carried out on Olympus microscope.

Table1: Chemical composition of the available alloy samples during the present investigation and the standard alloys.

Available Alloy specification	C	Mn	P	S	Si	Cr	Mo	Ni
1040	0.43	0.90	0.028	0.013	0.25	-	-	-
4140	0.39	0.90	0.022	0.0067	0.25	1.0	0.16	-
8640	0.4	0.95	0.019	0.02	0.25	0.5	0.16	0.05
Standard Alloy specification	**C**	**Mn**	**P**	**S**	**Si**	**Cr**	**Mo**	**Ni**
1040	0.37-0.40	0.60-0.90	Max.0.04	Max.0.05	0.15-0.35	-	-	-
4140	0.37-0.44	0.65-1.10	Max 0.035	Max.0.04	0.20-0.35	0.75-1.20	0.15-0.25	-
8640	0.37-0.44	0.70-1.05	Max 0.035	Max.0.04	0.20-0.35	0.35-0.65	0.15-0.25	0.35-0.75

RESULTS AND DISCUSSION

During the present research the hardenability profiles of non plated and plated samples had been recorded. These results are tabulated in Table 2 and their graphical representations are also shown in Fig.1, 3, 5, 7, 8 &9. It can be seen from table 2, that large variation in hardness values of plated and non plated samples of 1040 steels was due to decarburization. However the effect of decarburization in non plated and plated samples of alloy steels (4140 & 8640) was negligible (Table2). This shows that rate of decarburization in plain carbon steel was pronounced at elevated temperature.

Results obtained from experimental graphs for 1040 steel (plated) samples are:

1. Max. Average HRC for 1040 steel = 54HRC
2. Minimum. Average HRC for 1040 steel = 18HRC
3. Sharp drop in hardness J = 1appr.

According to standard graphs for 1040 steel:

1. Max. HRC for 1040-steel = 54-60HRC
2. Minimum. HRC for 1040-steel = 12-14HRC
3. Sharp drop in hardness J = 3-4 approx.

Both of the above results appear to be nearly true for experimental data obtained. The minute fluctuations in values are possibly due to longer time consumed in putting specimen in Jominy apparatus, variable water supply by WASA, Compositional mismatch and decarburization due to pealing off of copper-plating.

The microstructural study of 1040 sample revealed that away from the quenched end, the microstructure changed from martensite to pearlite and ferrite gradually. The Fig.2 (a) was taken from the quench end, consisted of martensite only. Slightly away from the quenched

end the microstructure was composed of martensite and pearlite Fig.2 (b). The micrograph shown in Fig.2(c) was taken from the distance of about one inch from the quench end.Fig.2 (d) was taken away from one inch. All these microstructural changes are in accordance with the hardness values recorded i.e. away from the quench end the amount of martensite is decreased while that of pearlite and ferrite increased. Similar behavior was observed in hardness (Table 2) i.e. at quenched end the hardness was approximately 54 HRC,while the hardness at a distance of approximately one inch away from the quench end was around 23 HRC.

Table 2 : Showing the results of hardness values at different distances along the quench end.(J=0 value was not consider due to decarburization & HRC values below 14 was also not taken into account due to machine error)

Alloy Spec.	1040 Steel		4140 Steel		8640 Steel	
J-distance	Plated Sample1	Non–plated sample 2	Plated sample 3	Non–plated sample 4	Plated sample 5	Non-plated sample 6
0(0)	54.3	27.4	55.4	57.5	51.6	53.2
1(1/16")1.5875mm	54.5	33.6	53.5	62	56	54.1
2	45.4	63.4	58.2	58.6	55.9	54.1
3	32.9	32.8	60.3	51.2	57.5	50.9
4	38.4	38.6	57.9	40.2	56.5	62.6
5	34.4	30.5	58	30.9	56.7	54
6	31.2	27.8	57.9	31.75	58.3	53.9
7	29.2	19.5	54.5	33.6	55.4	49.9
8	36	14.6	50.6	29.8	57.1	47.2
9	31.4	15	50.8	28.6	55.7	44.9
10	29.2	20.6	43	39.6	52.8	45.4
11	30.6	20	44.2	30.4	49.2	43.1
12	31.8	16.5	49.6	30.4	46.1	40
13	37	10.5	42.2	32.9	40	33.4
14	25.4		45.6	29.8	42.6	31.6
15	25.9		47.6	27.1	38.2	34.5
16	23		43	32.6	41.4	33.5
17(1/8")3.750mm	27.7		37	25.6	35.6	32.3
18	27.6		34.4	30.2	35.6	40.2
19	22		37.4	22.8	32.9	32.3
20	25.4		36.2	26.7	30.6	30.4
21	26		36	23.9	31.9	30
22	29		39	32.8	32.2	29.5
23	22.3		37.9	20.4	33.1	29.9
24	21		33.8	19.5	28.9	30
25	19.5		36.6	24.1	33.6	31.2
26	17.7		32.7	11.9	29.4	

The results obtained from the experimental graphs for 4140 steel samples (plated) are:

1. Average. Max. Hardness = 60HRC
2. Average minimum hardness = 32HRC
3. Sharp drop in hardness occurs at J = 6 or 7.

According to standard graphs for 4140 steel:

1. Max. Hardness = 58HRC

2. Minimum hardness = 33HRC

3. Sharp drop in hardness occurs at J = 6

It can be seen from the above results that both are matching each other.

Microstructural analysis as well as hardness data i.e. app.60HRC revealed the presence of martensite at the quenched end, Fig.4 (a). It was observed that away from the quench end the amount of martensite is decreased, Fig.4 (b, c) revealed the presence of bainite .Fig4 (d). In the microstructure of 4140 steel taken further away from quench end along with martensite and bainite very small amount of fine pearlite was also observed.

The results obtained from the experimental graphs for 8640 steel (plated) are:

1. Average Max hardness = 56HRC

2. Average minimum hardness = 32HRC

3. Sharp drop in hardness occurs at J = 10 or 12

According to standard graphs for 8640 steel:

1. Max hardness = 57HRC

2. Minimum hardness = 25HRC

3. Sharp drop in hardness occurs at J = 5

The changes in the above results may be due to compositional difference.
Fig.6 (a, b, c, d) The micrographs taken at the quench end and away from the quench end revealed the presence of martensite and bainite.

In microstructural comparison some similarities were found between 4140 and 8640 i.e. presence of martensite and bainite (revealed from their microstructures and as well as from their hardness values).But there was one difference i.e. absence of pearlite, in case of 8640 steel the amount of bainite gradually increased up to a distance of one inch and the average hardness was more than that of 4140 steel at each jominy distance as moved away from quenched end. It appears to be one of the advantages of presence of multiple alloying additions which ultimately increased the hardenability and inhibit decarburization. This effect is known as SYNERGESTIC EFFECT".

CONCLUSIONS

- Out of three steels investigated,8640-steel i.e. Ni-Cr-Mo-steel has high hardenability as compare to the plain-carbon steel(1040) and low alloy steel (4140 i.e. Cr-Mo–steel),due to synergistic effect of multiple alloying additions, that is why its high hardness remains up to jominy distance J=12apx.

- The scatter in the hardness profile is least for 8640 steel; hence negligible decarburization is exhibited by 8640 and 4140–steels as compared to1040-steel.

- Martensite is formed at least at the very end of the bars. The microstructural examination reveals that the samples went through different phases according to phase diagrams.

The regions at the quench end were cooled very fast so they did not get a chance to form pearlite as a result martensite formed. The region away from the quench end, air cooled, and had a chance to form some pearlite and ferrite, but they still cooled fast so the pearlite should be fine.

- There is great variation in the results in case of plated and non-plated samples of 1040-steel, however, negligible variation was found in case of plated and non-plated samples alloy steel. This shows that in case of plain carbon steel, plating is essential to overcome the decarburization effect.

REFERENCES

1. Metal hand book 9th edition, volume 1, properties and selection iron and steels, hardenability of carbon and alloy steel; 1978, page 471-525.

2. R. E. Reed Hill: Physical metallurgy principles second ed., D. Van nostrand company New York, 1973, pages 477-518.

3. M.A.Grossman, W.E Jominy, C.E post, G.C Riegel: Hardenability of steel: prepared under the direction of subcommittee on hardenability; pages 489-501.

4. B.Zakharo: Heat treatment of metals, Mir publisher, Mascow, 1962.

5. T.V.Rajan, C.P.sharma and A. Sharma: Heat treatment principles and techniques, Prentice Hall of India Pvt. Ltd, Delhi, 1997.

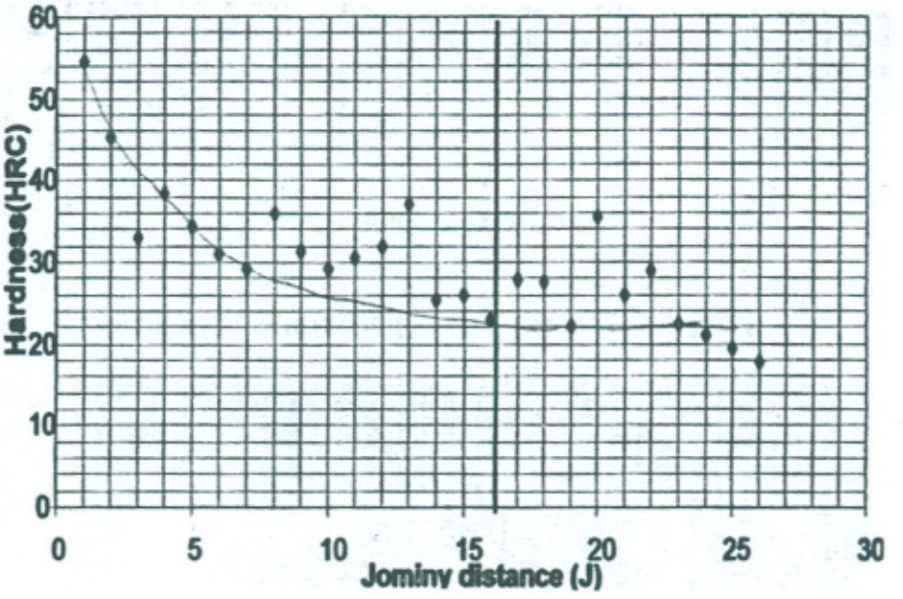


Fig 1: Hardenability curve of 1040 steel sample (Cu- plated)

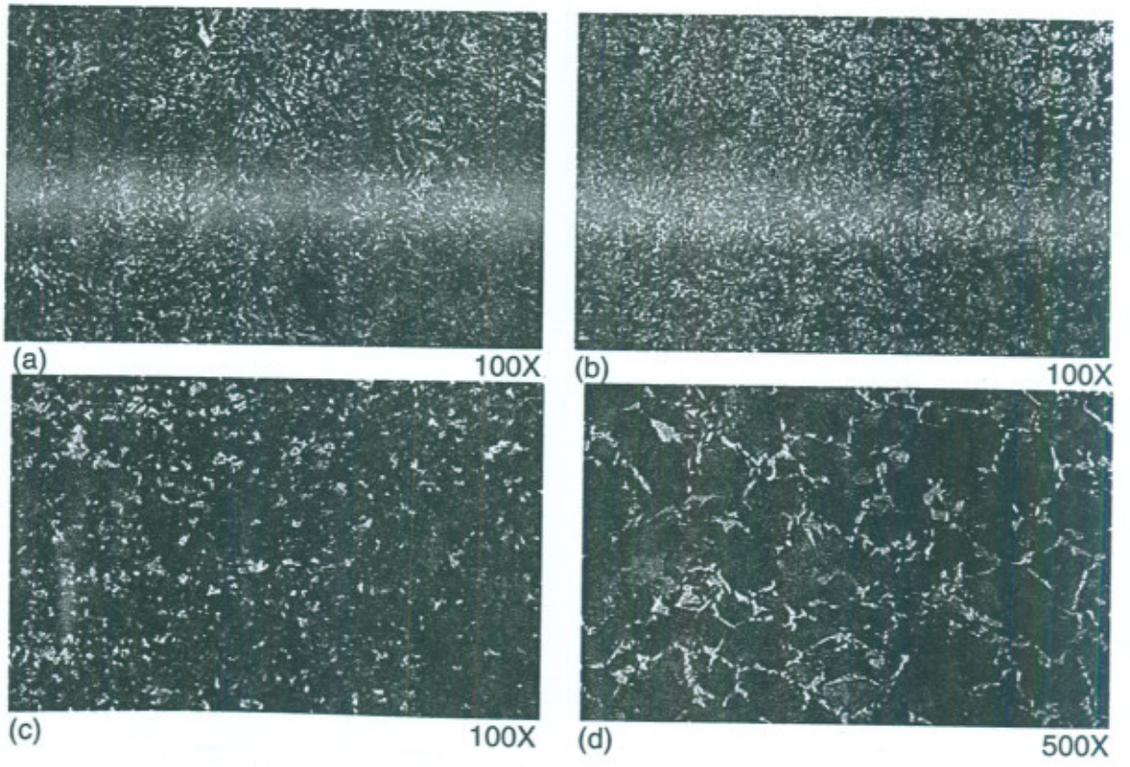


Fig2. Micrographs taken at quench end (a) and further away from quench end (b) revealed the presence of martensite (grayish) & pearlite (black). (c, d) Micrographs taken further away from quench end revealed the presence of martensite, pearlite and ferrite at the grain boundaries.

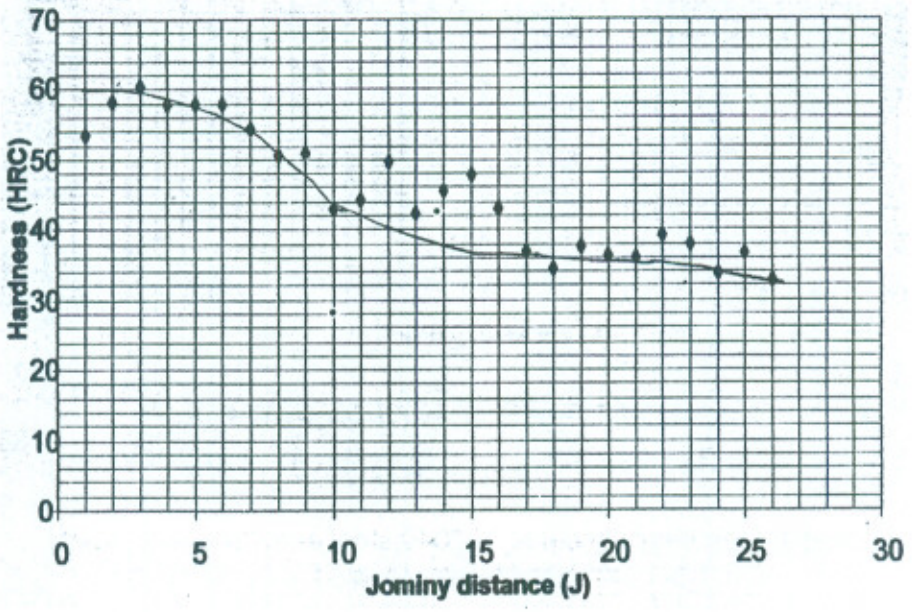


Fig 3: Hardenability curve of 4140 steel sample (Cu-plated)

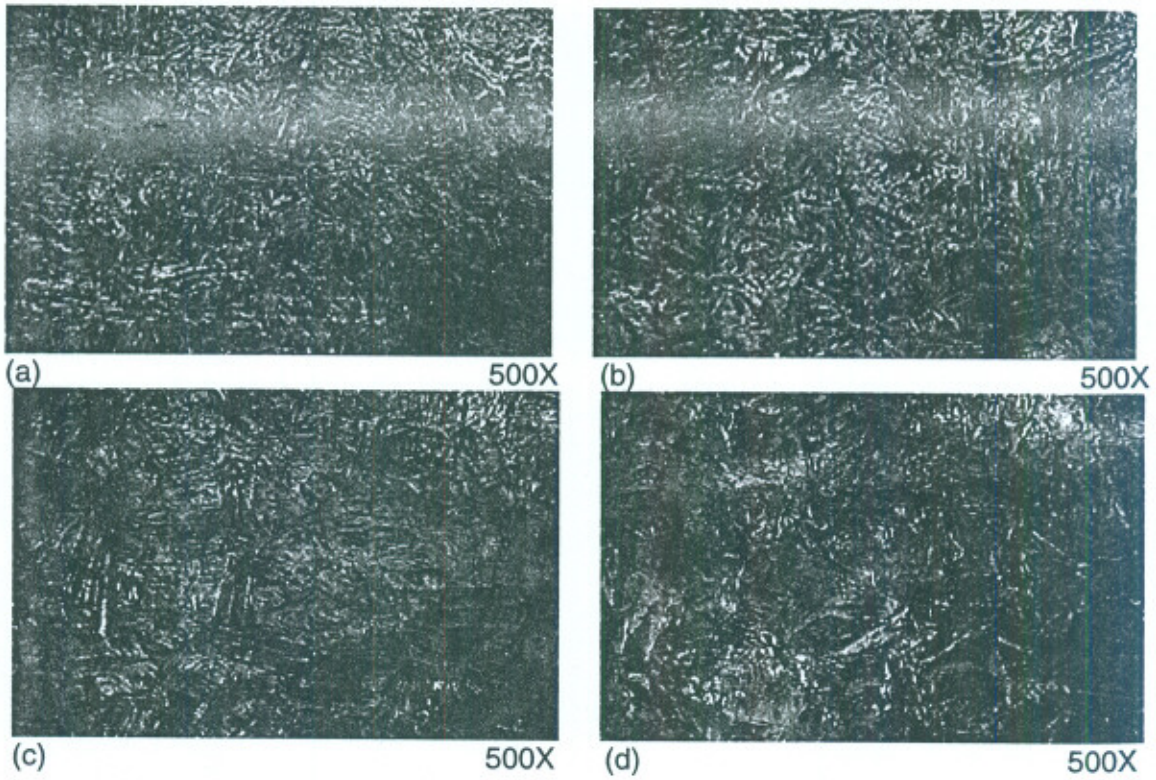


Fig4.(a)Micrographs taken at quench end revealed the presence of martensite (grayish).Micrographs taken near to the quench end (b) and further away from quench end (c) revealed the presence of martensite and bainite (dark feathery area). (d)Micrograph taken nearly at a distance of one inch from the quench end revealed the presence of martensite, bainite and some fine pearlite (black).

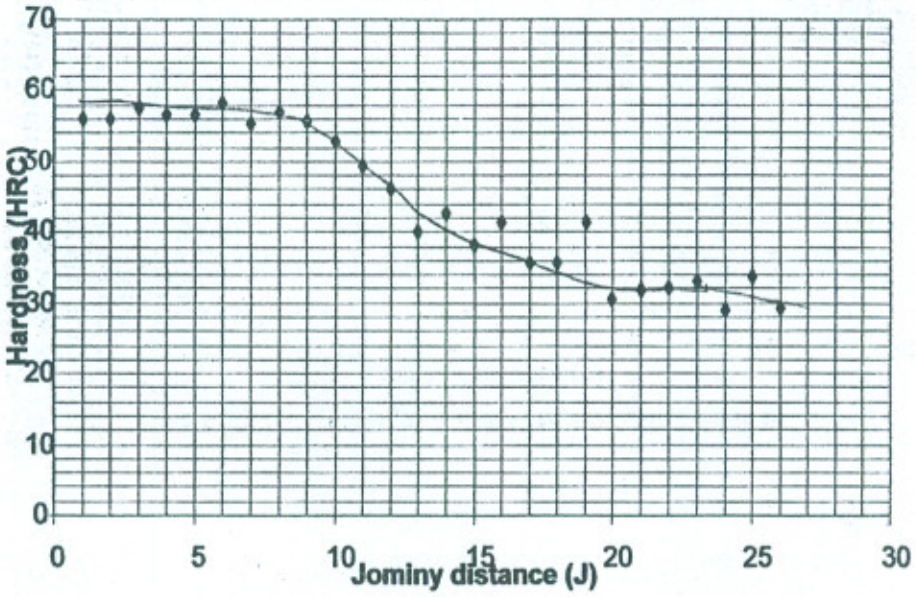


Fig 5: Hardenability curve of 8640 steel sample (Cu-plated)

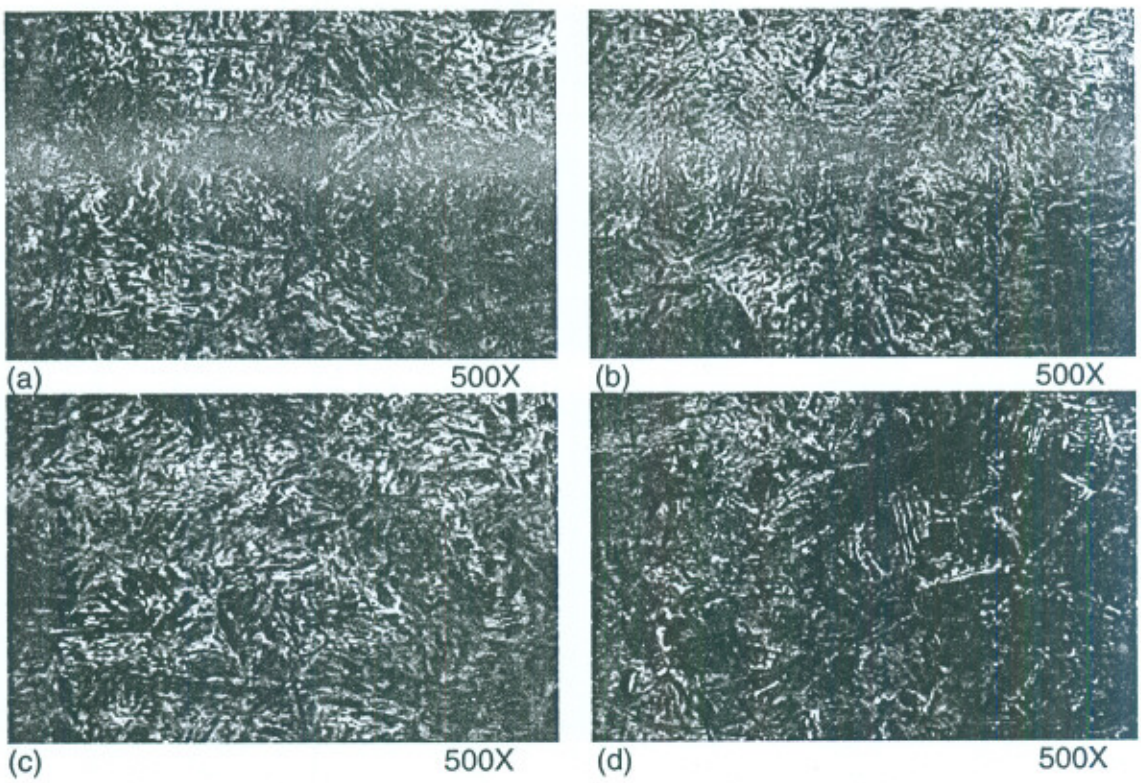


Fig. 6 (a).Micrograph taken at quench end revealed the presence of martensite (grayish) and dark etching bainite, (b) near to quench end revealed the presence of martensite and bainite,(c) further away from quench end revealed the presence of martensite and bainite,(d) micrographs taken at distance of approximately one inch away from quench end revealed the presence of martensite (grayish) and bainite(dark)& the amount of bainite has increased.

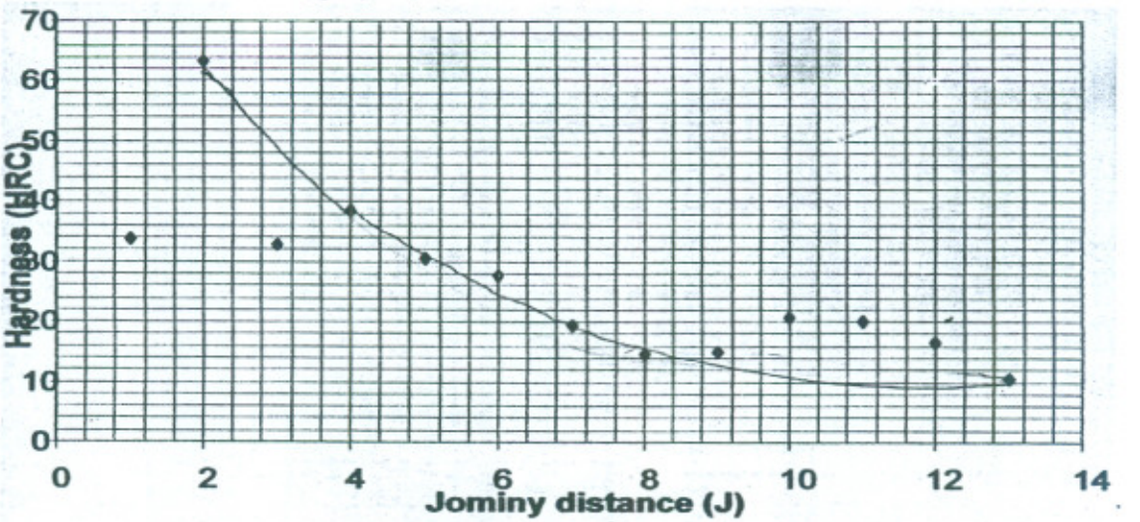


Fig 7:Hardenability curve of 1040 steel sample (non- plated)

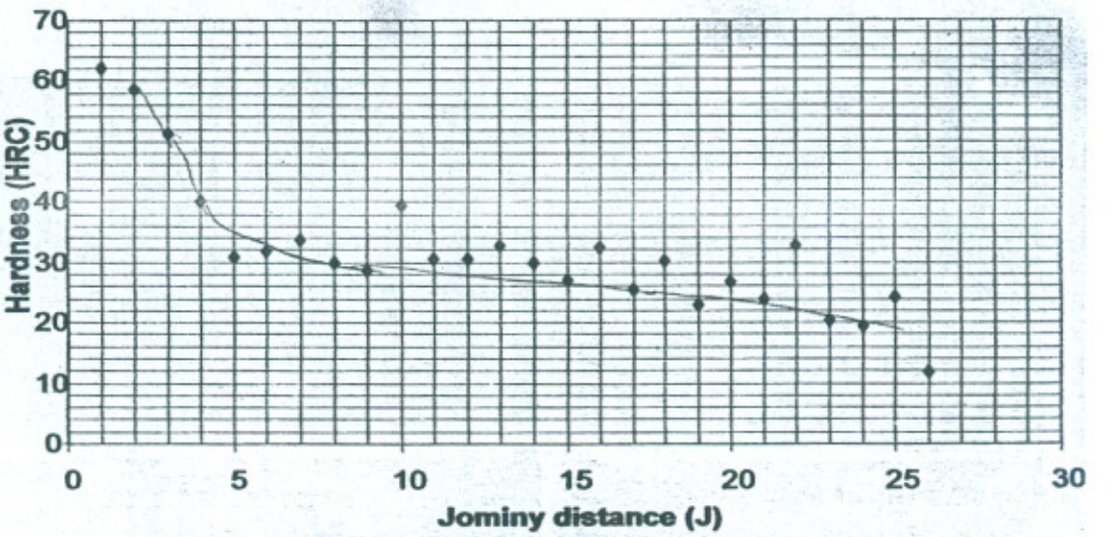


Fig 8: Hardenability curve of 4140 steel sample (non- plated)

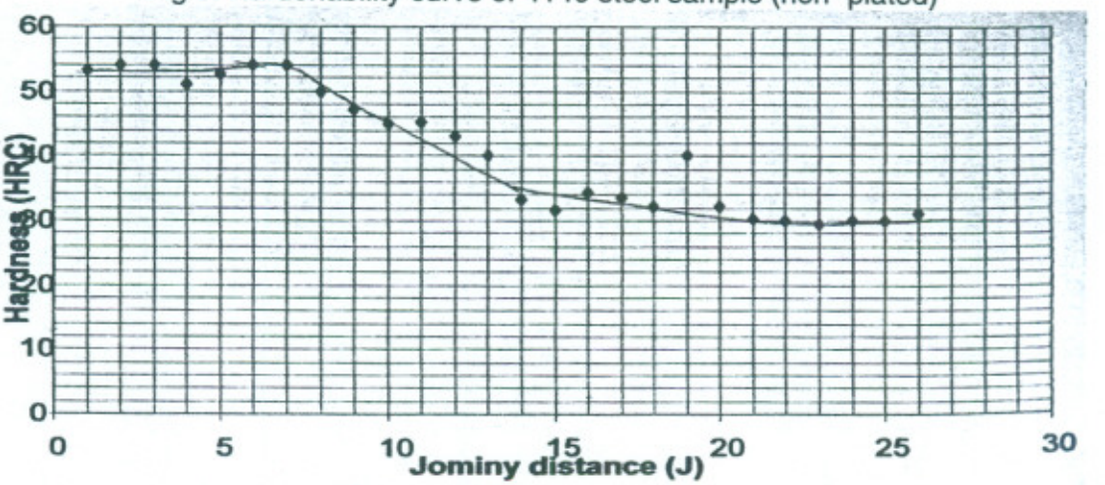


Fig 9:Hardenability curve of 8640 steel sample (non- plated)

DENSIFICTION OF STEEL THROUGH HOT-SINTERING AND THE RESETTING HARDNESS

By

Dr. Liaqat Ali* and Gul Hameed Awan**

ABSTRACT

Sintered steels containing silicon and manganese as main alloying constituents were prepared by hot sintering process. Four types of mixtures were prepared by using annealed and unannealed master alloy additions. These were identified as A, B, C and D. Mixtures A and C were prepared by using annealed master alloys and mixtures B and D from unannealed master alloys. Mixtures A and B were sintered over a range 1160°C to 1170°C while mixtures C and D were sintered between 1130°C to 1140°C. The annealed mixtures had lower values of porosity and higher hardness. It was shown that the lower porosity and higher hardness could be related partly to the silicon content of one of the master alloy mixtures; the presence of silicon caused an increase in the diffusion of alloying elements due to the decreased interfacial energy at the liquid- solid interface.

1. INTRODUCTION

Several approaches have been worked out by powder metallurgists to improve the strength of sintered iron and steel using alloying techniques and heat treatments. Studies of the effect of alloying on the mechanical properties of iron and steel have been made using different alloying addition method (1-4).

In addition to mechanical properties, the cost of sintered powder metallurgy parts is also an important consideration. Attempts have been made to develop new alloying systems on the basis of more economic elements than the metal used such as copper, nickel and molybdenum. A suitable element in principle is silicon which has been shown to have an excellent strengthening effect in sintered steel [4]. However, its addition leads to an excessive shrinkage of binary iron-silicon compact in the range of usual composition and sintering conditions. Manganese, on the other hand, overcomes the shrinkage problem of iron-silicon by stabilizing the face centre cubic γ phase. Moreover manganese is available at low cost and also increases the strength of the system.

In the work reported here, the effect of sintering temperature on the porosity and hardness values in iron-base alloys containing an addition of a silicon manganese master alloy [5] have been studied.

2. EXPERIMENTAL

The specification of the powder used for making mixtures was:

Apparent density, g/cm^3	=	2.95 ± 0.10
Flow, sec/50 g	==	Maximum 30
Compressibility, g/cm^3	=—	Minimum 6.80

This powder was sieved and. the -350# fraction used for experimental work.

---

*Professor, Department of Metallurgical & Materials Engineering, University of Engineering and Technology, Lahore.

**Associate Professor, Department of Metallurgical & Materials Engineering, University of Engineering and

Technology, Lahore.

Alloying Addition

The alloying elements were added in the form of a master alloy containing iron, silicon and manganese. Two master alloys having compositions: 53% iron, 31% manganese, 16% silicon and 40% iron, 49% manganese, 11% silicon were treated separately.

Milling

As received master alloys were milled in a high energy mill for three hours and sieved and the minus 350# size was used for alloying; two mixtures were prepared from this powder and the other two mixtures were prepared using annealed master alloy addition.

Annealing

Minus 350# fractions of master alloy were annealed in a hydrogen atmosphere at 900°C for one hour and furnace cooled.

Addition of Lubricant

The lubricant, 0.7% zinc stearate was introduced as a fine powder and mixed with the metal powders by milling.

Addition of Carbon

Fine graphite, as used by GKN (Guest Keen Nettleford, GTC Research Centre, Wolverhampton), powder was used for the carbon additions; 0.4 weight percent was used in all mixtures.

Mixing

Batches of about 250 gms of a mixture of iron powder, master alloy, lubricant and graphite were mixed in a laboratory ball mill for thirty minutes.

Preparation of Mixture

Four mixtures, prepared from the two different ternary master alloys were identified as follows:

2.1 Mixture - A

Annealed master alloy having 53% iron, 31% manganese and 16% silicon, the final composition was as follows:

Mixture A	Carbon Wt. %	Manganese Wt. %	Silicon Wt. %	Iron Wt. %
	0.40	3.20	1.65	94.75

Mixture - B

Unannealed ternary master alloy was used, providing a final composition as follows:

Mixture B	Carbon Wt. %	Manganese Wt. %	Silicon Wt. %	Iron Wt. %
	0.40	3.20	1.65	94.75

Mixture - C

Annealed master alloy with 40% iron, 49% manganese and 11% silicon was used, providing a final composition as follows:

Mixture C	Carbon Wt. %	Manganese Wt. %	Silicon Wt. %	Iron Wt. %
	0.40	3.20	0.72	95.68

Mixture - D

Unannealed ternary master alloy was used, providing the final composition listed below:

Mixture D	Carbon Wt. %	Manganese Wt. %	Silicon Wt. %	Iron Wt. %
	0.40	3.20	0.72	95.68

2.2 Sintering

Sintering was carried out in a muffle furnace for 50 minutes in a hydrogen atmosphere. The 53% iron – 31% manganese and 16% silicon master alloy showed a melting range of 1130°C to 1168°C and therefore, sintering of mixtures A and B was carried out at temperature of 1160°C,1165°C and 1170°C. The 40% iron – 49% manganese and 11% silicon master alloy had a melting range of 1117°C to 1140°C; consequently sintering of mixtures C and D was carried out at 1130°C, 1135°C and 1140°C. Finally the samples were normalized.

Specimens were polished using conventional techniques, Unetched polished specimens were examined for porosity measurement. Hardness were determined using a vicker Indentor at a load of 20 kg.

3. RESULTS

The porosity and hardness measurements are classified for the two types of master alloys used.

3.1 Group – 1 (53% Fe – 31% Mn – 16% Si Master alloy)

Porosity and Hardness

The results are given below in Tables 1 and 2.

Table 1: Mixture – A: Annealed Powder

Temperature °C	1160 ± 1	1165 ± 1	1170 ± 1
Porosity %	5.20 ± 0.2	3.80 ± 0.2	3.00 ± 0.2
Hardness HV20	139 ± 2	157 ± 2	172 ± 2

Table 2: Mixture – B: Unannealed Powder

Temperature °C	1160 ± 1	1165 ± 1	1170 ± 1
Porosity %	6.51 ± 0.2	5.00 ± 0.2	3.78 ± 0.2
Hardness HV20	122 ± 2	143 ± 2	160 ± 2

The results are shown graphically in Figs. 1 & 2. It can be seen that the porosity decreases with increasing temperature (Fig. 1) while the hardness increases with temperature (Fig. 2).

3.2 Group – 2 (40% Fe – 49% Mn – 11% Si)

Porosity and Hardness

The results are given below in Tables 3 and 4.

Table 3: Mixture – C: Annealed Powder

Temperature °C	1130 ± 1	1135 ± 1	1140 ± 1
Porosity %	7.24 ± 0.2	5.23 ± 0.2	4.33 ± 0.2
Hardness HV20	110 ± 2	134 ± 2	146 ± 2

Table 4: Mixture – D: Unannealed Powder

Temperature °C	1130 ± 1	1135 ± 1	1140 ± 1
Porosity %	7.60 ± 0.2	5.66 ± 0.2	4.80 ± 0.2
Hardness HV20	103 ± 2	124 ± 2	137 ± 2

The results are shown graphically in Figs. 3 & 4. These show that the porosity decreases with increasing temperature (Fig. 3) while the hardness increases with temperature (Fig. 4).

4. DISCUSSION

The porosity of a number of specimens was measured to determine the effect of sintering temperatures on densification.

The results for samples containing annealed and unannealed (mixtures A and B) master alloy at 1160°C, 1165°C and 1170°C and for mixtures C and D at 1130°C, 1135°C and 1140°C are shown graphically in Figures 1 and 3, respectively. It can be seen that, as expected, the total sample porosity decreases with increasing temperature; about 45% reduction in porosity is attained in specimens sintered at 1170°C compared to 1160°C sintered.

A low value of dihedral angle (low value of γ_{SL}) would cause the liquid phase to spread thinly around the particle boundaries thereby covering a large surface area of the iron particles and thus reducing the diffusion distance for material transport during sintering, in which the solid-liquid interface moves towards the liquid phase. This results in faster penetration of liquid phase along the grain boundaries and into the pores. Conversely, a large dihedral angle results in slow penetration of liquid phase along the grain boundaries and into the pores. The high porosity at low temperatures is associated with large dihedral angle.

The results for samples containing annealed and unannealed (Mixtures A and B) master alloy at 1160°C, 1165 °C and 1170°C and for Mixtures C and D at 1130°C , 1135°C and 1140°C are shown graphically in Figures 2 and 4 respectively. It can be seen that the average hardness increases with increasing temperature; the average hardness (HVN 20) at 1170°C is 172 and 160 for mixtures A and B (Tables 1 and 2) whereas at 1160°C hardness of 139 and 122 are obtained. The high hardness value at higher temperature is related to the low value of dihedral angle. However, the linking of dihedral angle with hardness is perhaps a second order effect and the first order effect is probably due to the increased substitutional and interstitial solution. Additionally, a reduction in porosity at higher temperature (Figs. 1 and 3) yields a more dense compact and consequently an increased bulk hardness. The effect of solution hardening is not so easily quantified because of the presence of carbon and the amount of pearlite formed; as an empirical observation, an increase in sintering temperature gives rise to a harder compact.

Annealing in hydrogen of the master alloys before compaction, for the two mixtures, produces an effect on the porosity and hardness.

Fi

The annealed master alloy mixtures A and C are associated with lower porosity

(Figs. 1 & 3) with higher hardness (Figs. 2 and 4) compared to the unannealed state (mixtures B and D).

It seems possible that hydrogen annealing removes oxides and other surface contaminants from individual particles of the master alloy. This provides a more intimate contact between particle's and the liquid phase during sintering. The wettability is, therefore, increased as a consequence of annealing and lower dihedral angles are obtained. Furthermore the removal of oxides and surface contaminants contribute towards an increase in the green density of a compact as a consequence of more contact between the particles. This may be due to the change of porosity shape with a consequent change in the liquid capillary system.

5. CONCLUSIONS

1. Hydrogen annealing of both master alloys is found to lower the porosity and higher hardness value.
2. The mixture containing more silicon in the master alloy possesses greater strength, high density and low porosity; this is probably because of enhanced solution of manganese and silicon in the iron particles.
3. The sintering temperature has great influence on the porosity and hardness. The porosity decreases with increasing temperature while the hardness increases with temperature.

6. REFERENCES

1. Klein, A.N., Oberacker, R. and Thummler, F. "Powder Metallurgy International", 1985, 17 (2), p.13-16.
2. Klein, A.N., Klausmann, R, Oberacker, R, and Thummler, F. University Karlsruhe and Nuclear Research Centre, Karlsruhe, FRG.
3. Zapf, G., and Dalal, K, "Modern Developments in Powder Metallurgy", 1977. 10, p.129-152.
4. Hoffmann, G., Thummler, F, and Zapf, G, 3rd Eurpo. Powder Metallurgy Symposium, 1971, pp 335-361.
5. Klein, A.N, , Oberacker, R, and Thummler, F. International Powder Metallurgy Conference, Toronto, 1984.

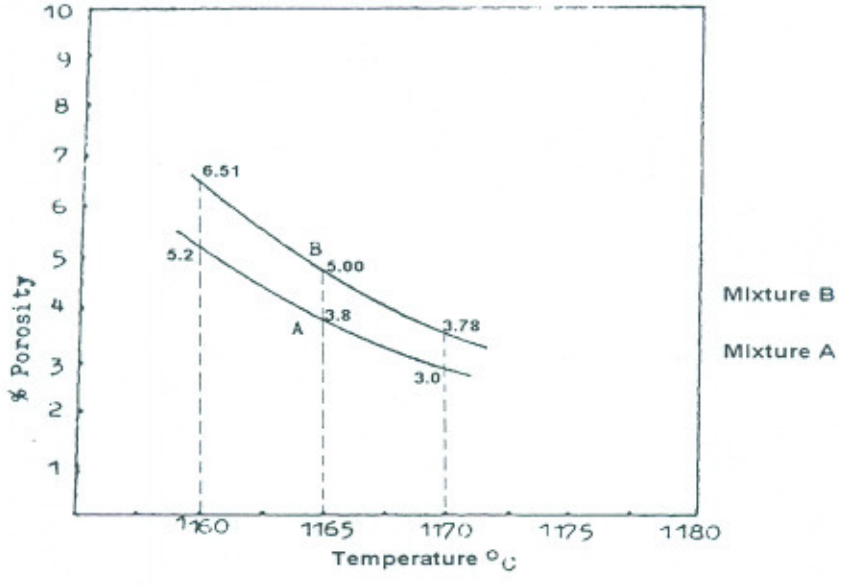


Fig. 1: Porosity of mixture A and B as a function of sintering temperature.

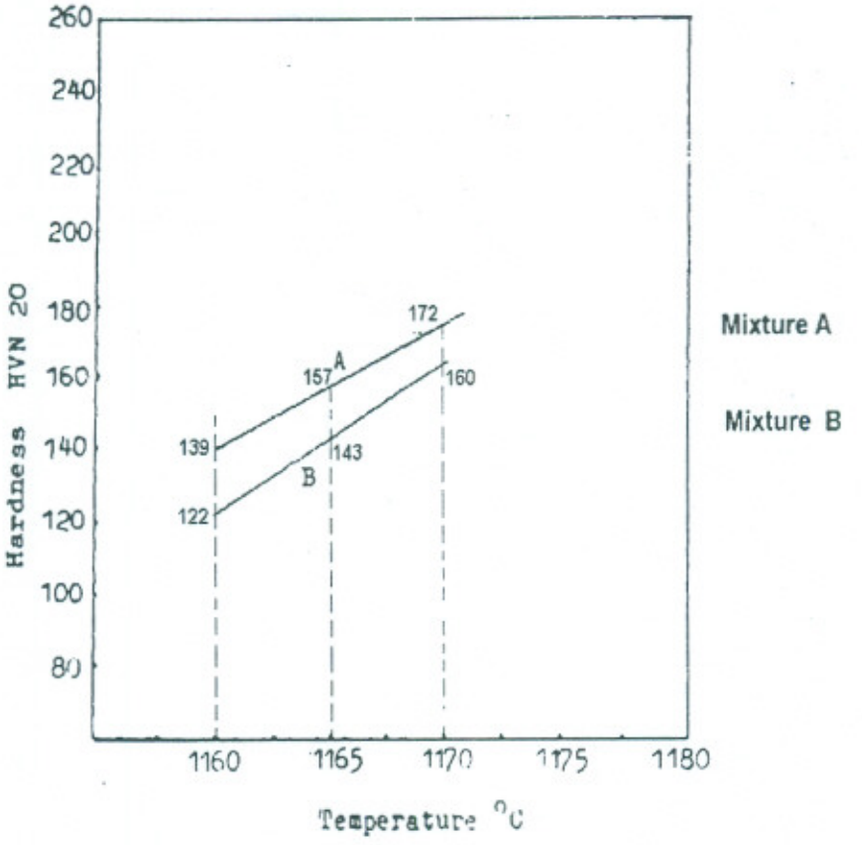


Fig. 2: Hardness of mixtures A and B as a function of sintering temperature.

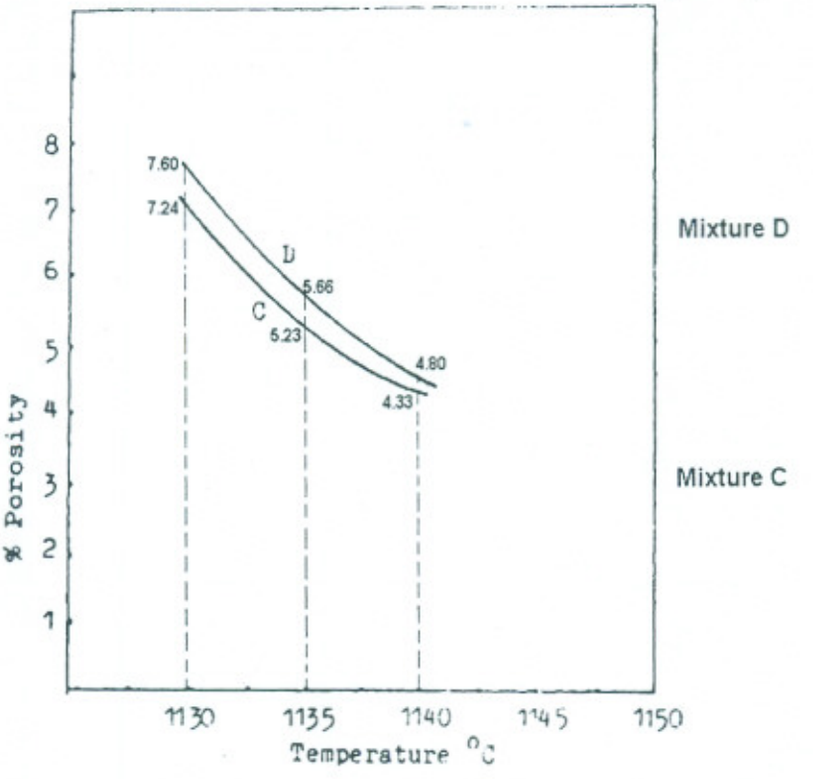


Fig. 3: Porosity of mixture C and D as a function of sintering temperature

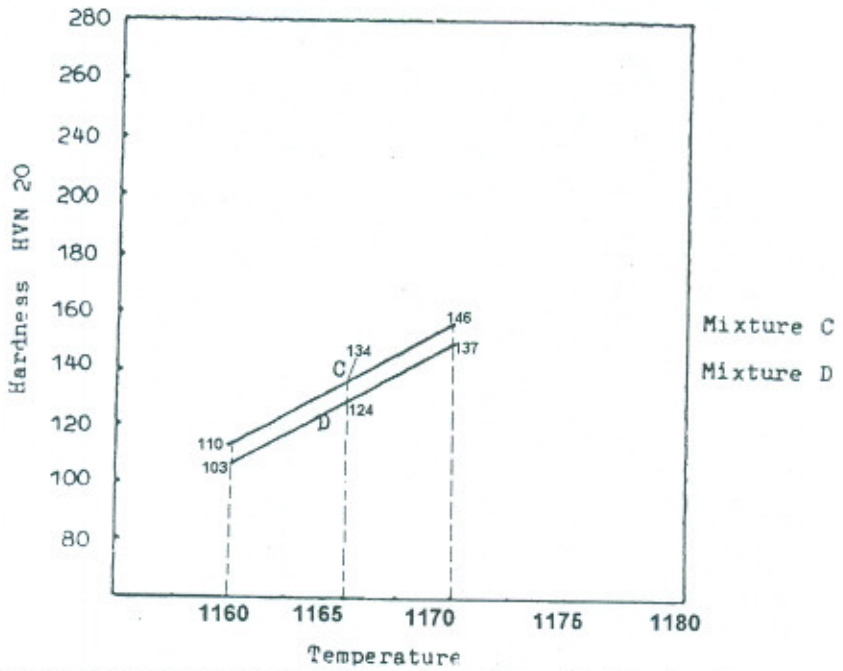


Fig. 4: Hardness of mixtures C and D as a function of sintering temperature.

INCREASE IN SURFACE HARDNESS OF SG IRON AND HIGH CARBON STEEL BY A PACK CHROMIZING TECHNIQUE

By

Rizwan Ahmad*, M. A. Raza, A. Salam*** and J. Ahmad******

ABSTRACT

The surface hardness of SG iron and a high carbon steel was increased for improvement in wear and fatigue resistance, by using a pack chromizing technique. Chromium powder with ammonium chloride was used as the chromizing mixture. The surface hardness of SG iron increased to 795 VPN from 172 VPN whereas the hardness of high carbon steel was found to be 367 VPN after chromizing as compared to 185 VPN. The percentage increase in surface hardness of SG iron is greater than high carbon steel.

INTRODUCTION

Diffusion chromizing is an important industrial technique which is employed to increase the surface hardness of many steels and cast iron parts. The process involves diffusion of chromium into the surface of the metal to be chromized, providing direct coating of a layer of chromium.

Diffusion chromizing is carried out to increase the wear resistance including cavitation and erosion at low and high temperatures, and fatigue resistance which may be mechanical, thermal or corrosion. There are a number of industrial applications of diffusion chromizing. These include exhaust systems of engines, gas turbine blades, nozzles and atomizers operating under conditions of corrosion, diesel engine valves, grates of gas stores, atomizers for fuel oils and parts of heat exchangers.

At present diffusion chromizing of iron carbon alloys is possible by four methods namely solid, vapour, gas and liquid phase chromizing. One of these methods consists of packing of steel and cast iron parts in containers with a special powder composed of a mixture of chromium powder or low carbon ferrochrome, aluminium oxide or fire clay and ammonium chloride. The container are placed in furnace and heated at a temperature in the range 950 °C to 1050 °C for 8 to 15 hours. During this period, the chromium difuses inward, saturating a case of depth from 0.05 to 0.15 mm. In the present work, diffusion chromizing of a high carbon steel and SG iron has been carried out by a similar technique using chromium powder and ammonium chloride as the chromizing mixture, in order to improve wear and fatigue resistance which is often desirable for industrial applications.

EXPERIMENTAL METHODS

The specimens were turned and cut from high carbon steel and SG iron bars of 13mm diameter. After cutting, the specimens were cleaned with emery paper so that the rust and scale was removed. All the specimens were dipped in boiling NaOH solution and rinsed with tap water to remove the traces of oil. The specimens were then dried and made ready for packing.

---

*, **, ***, ****Metallurgy and Material Science Division, Institute of Chemical Engineering & Technology, University of the Punjab, Lahore.

Initially a layer of 25mm mixture of chromium powder and ammonium chloride was spread on the bottom of the container. The specimens to be chromized were placed on this layer in such a manner that they were separated by 15mm from each other and 20mm from walls. The specimens were covered by a 10mm layer of the mixture. Again the specimens were placed on this layer and covered by the chromizing mixture and this layer was leveled and lightly rammed by a wooden hammer. Then lid was placed on the container and was packed by fireclay. After packing the specimens in the container, the container was placed in the furnace at temperature of 1000 C°. The specimens were heated at this temperature for 8 hours. After 8 hours the container was unloaded and cooled down to room temperature. The specimens were removed, scraped with wood to remove the clinging particles and washed in clean water.

After Chromizing, the specimens were prepared for the hardness determination by Vickers Hardness testing machine with a 5 kg load.

RESULTS AND DISCUSSION

The case hardness values of high carbon steel and SG iron specimens, chromized in a chromium powder- NH_4Cl mixture were obtained by using Vickers hardness tester and the results are given in Table 1. The specimens were chromized at 1000 °C for 8 hours. It may be seen that the hardness increases in case of both SG iron and high carbon steel specimens. In SG iron, the hardness increases from 172 VPN to 795 VPN and in high carbon steel, the hardness increase is from 185 VPN to 367 VPN. This corresponds to a percentage increase of 362% in hardness for SG iron and an increase of 98% for high carbon steel. The increase in surface (case) hardness of SG iron is seen to be greater as compared to high carbon steel. The easy chromizeability of SG iron in comparison with steel may be attributed to the presence of free carbon where as in steels carbon occurs in combined form as carbide. During the chromizing of steel, dissociation of the carbide phase precedes the diffusion of carbon atoms towards chromium. Therefore, more time is required for chromium carbide formation. On the other hand in SG iron, all the carbon is not in combined form. This allows diffusion of carbon atoms towards the surface and formation of the carbide phase relatively easily.

Table 1.

Material	Core hardness of Unchromized specimens (VPN)	Case hardness of chromized specimens (VPN)	% increase in hardness
Cast iron (SG)	172	795	362%
High Carbon Steel	185	367	98%

CONCLUSIONS

1. The surface hardness of SG iron and a high carbon steel has been successfully increased by a pack chromizing technique using a chromium powder and ammonium chloride mixture.
2. The surface hardness of SG iron increased to 795 VPN from 172 VPN after chromizing.
3. The surface hardness of high carbon steel increased to 367 VPN from 185 VPN after chromizing.
4. The increase in surface hardness of SG iron was greater as compared to high carbon steel.

GENERAL REFERENCES

1. H. Chessin and E.H.Fernald, "Metals handbook", 1982, American society for metals, USA, Vol.5, 170 to 187.
2. W.D. Callister, "Materials Science and Engineering", ed.5, 1999, John Wiley & sons, USA.
3. H.Sidney Avner, "Introduction to Physical metallurgy", ed.2, 1974, McGraw-Hill Singapore.
4. F. William Smith, "Principles of materials science and Engineering", ed.3, 1996, Mc Graw-Hill, USA.

HARNESSING THE STREAMS AND SETTING MANAGEMENT OF SUSTAINABLE WATER RESOURCES DEVELOPMENT

By

I. B. Sheikh

ABSTRACT

Pakistan with a Geographical area of 796,101 square kilometers possesses a large river like Indus, which along with its tributaries namely Chenab, Jhelum, Ravi, Kabul and Sutlej, forms one of the mightiest river systems of the world. This system comprises 3 super storage reservoirs, 19 large river headworks, 45 cana1s providing a system measuring 63,000 kilometers, some 1.6 million kilometers of water courses and 94 large dams of height 15 meter and above. The progress and well being of a nation, inter-alia, depends on water resources development (Surface & Groundwater Reservoir, Canal Network and Drainage System). Agriculture, being the main source or crop production and necessity for the existence of human being and all kinds of animals, directly depends upon the availability of appropriate quantity and quality of water at proper time. The fertility of land and yield of crops gets affected due to the unavailability of suitable water in arid area and standing of surplus water in the waterlogged area.

In this paper, attempt has been made to increase the availability of water by proposing new projects and techniques in the arid/ semi-arid areas of Balochistan, and construction of small dams/ delay action dams. The paper includes the study of delay action dams in specific areas of Balochistan along with the nature of soil in the area. The nature of vegetative cover and climatic conditions, Hydro-geologic situation and the environmental and socio-economic impacts of delay Action Dams have also been studied.

INTRODUCTION

Pakistan with a geographical area of 796,101 square kilometers possesses large river like Indus, which along with its 5 tributaries, namely Chenab, Jhelum, Ravi, Kabul and Sutlej, forms one of the mightiest river Systems of the world. The river System comprises 3 storage reservoirs, 19 large rivers headworks, 45 Canal System measuring 61,000 kilometers, some 1.6 million kilometers of watercourses and field Irrigation Channels. Pakistan has big rivers like Indus, Chenab, Ravi, Jhelum and Sutlej, where discharges in summer season vary from 100 thousand cusecs to 1200 thousand cusecs (3 thousand to 34 thousand cumecs) and cause tremendous loss to human lives, crops and property. Due to limited capacity of storage at Tarbela and Mangla Dams on river Indus and Jhelum respectively and with virtually no control on river Chenab, Ravi and Sutlej, devastating flood problems are faced between July and October in the event of excessive rainfall in the catchments.

Pakistan comprises four major administrative units: Punjab, Sindh, North West Frontier Province and Balochistan, besides the Federally Administered Tribal and Northern Areas. Pakistan's population as estimated in 2004 is 149 million. The population growth rate is estimated at 2.1 %. The overall population density is 174.63 persons per kilometer. However, there is large regional variation in population density. Pakistan is a country with a very diverse social and geographic landscape. It comprises high mountains in the north, to desolate plateaus, fertile plains, sandy deserts, coastal beaches and mangrove forests in the south. It has the largest share of the highest mountain peaks in the world and has more

glaciers than any other land outside the North and South Poles. Pakistan's glacial area covers some] 3,680 sq.km, which represents an average of 13 percent of mountain regions of the upper Indus Basin.

THE IRRIGATION NETWORK

The Irrigation System of Pakistan is the largest integrated irrigation network in the world, serving over 42.00 million acres (17.00 million ha) of contiguous cultivated land. The waters of the Indus River and its tributaries feed the system. The salient features of the system are three major storage reservoirs, namely Tarbela and Chashma on River Indus and Mangla on River Jhelum with a present live storage of about 14.93 BM^3 (12.135 MAF), 19 barrages; 12 inter-river link canals and 45 independent irrigation canal commands. The total length of main canals alone is 63,000 Km. Water courses comprise another 1,621,000 Kms.

Diversion of river waters into canals is made through barrages, which are gated diversion weirs and a system of link canals. The main canals in turn deliver water to branch canals, distributaries and minors. The watercourses get their share of water through outlets in the irrigation channels. Distribution of water from a watercourse is effected through a time-schedule or "warabandi" under which each farm gets water for a specified period once a week. The time-share of "wari" is proportionate to the farm area owned by a farmer under the command of the watercourse.

The system draws an average of 106 MAF (131 BM^3) of surface water each year for irrigation supplemented by average annual groundwater pumpage of some 50 MAF, the average depth of water available at the farm gate is 3.07 feet per acre. Approximately 3 million individual farms with an average size of about 12 acres (5 ha) benefit from this system.

Pakistan has a diverse agro-ecological setting and is divided into three hydrological regions; the Indus Basin which is the major source of Pakistan's water, the Kharan desert in West Balochistan, with inland drainage and the arid Makran coast along the Arabian Sea in the Southern part of Balochistan. The deserts in the south (Thar and Cholistan) have no water resources. Most of the Indus Basin has been formed as a result of alluvial deposits brought by rivers from the mountainous ranges in the north. The flows in the Indus River are from glacial snowmelt including rainfall runoff outside the Indus Plains. Under the Indus Water Treaty of 1960, the flow of the three eastern rivers, the Sutlej, Beas and Ravi have been allocated to India and water from the three western rivers the Indus, Jhelum and Chenab is available for Pakistan.

Balochistan, area wise, the largest province accounting for 43.61 per cent of the total area of Pakistan but only 5.1 per cent of the total population. However, out of total 19.4 million hectares only 2.07 million hectares are being cultivated due to shortage of water. Its population is forecast to grow to 9 million by the year 2010. Most of the districts of Balochistan are suffering from severe water shortage. The domestic water demand which was 25 million cubic meters in 1950 has now increased to 395 million cubic meters and with the increase in population will be about 525 million cubic meters by the year 20 I O. However, the increase in demand for agriculture and industrial supplies is' much higher than its present availability. The drought condition during the prevailing few years has further exerted pressure on the already dwindling natural water resources such as Kareze, springs and seasonal water channels.

The use of tube wells throughout the province though has brought many barren areas into cultivation but they have affected the groundwater levels resulting in drying up of many Karezes and wells. Investigation carried out before the drought shows that 2 out of 14 basins, Pishin Lora and Nari are completely exhausted, whereas 6 out of the 12 remaining

basins have used more than 80 per cent of their water resources. In other basins the water table is falling rapidly. . Therefore, there is an urgent need to undertake measures to recharge the depleting aquifers. Balochistan is geographically the largest of the four provinces measuring 347190 sq. km in the southwest of Pakistan but has the smallest population, approximately 7450000(5% of total population). The population density is very low due to mountainous terrain and scarcity of water. Most of its land is high barren plateau 1000 to 1250 meters (3000 to 4000 feet) above mean sea level, enclosed by the Toba Kakar Mountain range along the Afghanistan border and by the Suleman Range bordering the Indus River. To the south lies one of the most inhospitable deserts in the world, the Makran and the Arabian Sea. There is low rainfall throughout ranging from 3 to 5 inches in the plain to a maximum of 12 inches in the hills.

With such low rainfall and hot climate water is scarce and is put to the best use. It has reputedly the hottest places in the country, Sibi and Dhadar, with temperature over 120 FO (49C°) and some of the coldest towns, (like Quetta, Kalat, Ziarat and Kan Mehtarzai. Balochistan has suffered significant damage due to regular floods, in particular the floods of 1973, 1975, 1976, 1978, 1982, 1992, 1994, 2003, 2004 and 2005. These caused damages to the agricultural lands, houses and infrastructure located in the vicinity of the different areas. In the high regions flashy hill torrents emanating from steep denuded hills cause devastation to large areas because of high velocity and unpredictable magnitude. Major infrastructure and roads network has been affected, with disruption to traffic flow.

STUDIES AREA

The following specific areas of Balochistan heave been considered for the study concerned

CATCHEMENT AREA OF SOUTHGAN NULLAH DISTRICT KHARAN:

Surrounding Area of Southgan nullah situated at about 18 km towards northeast from Kharan town, in district Kharan has been considered for study. The study area falls in the sub-tropical continental hyper-arid Mediterranean climate. The climate of the Kharan is dry; dust storms are common through out the year. During the summer season, days are hot but nights are very pleasant and cool. The winter is dry and cold. In the area temperature varies between 5 and 45 °C with rare incidence of frost or snowfall. Mean annual rainfall in the Kharan Valley is less than 15 cm. Winter rain showers and snowfall generally have low erosivity, while monsoonal rains in the area are highly erosive causing floods in the local streams.

Texture of Soil, Landform, Vegetation and water resources.

The study area is a part of the Chaghai-Kharan Basin and comprises plain landforms surrounded by mountains. The soils in the plain are mainly formed from mixtures of sand and loess washed from the mountains. The soils are strongly calcareous with 18-20 % lime content uniformly distributed in the profile. Drainage of the soils is good due to their homogenous porous structure. The surface of the surrounding mountains and hill slopes is bare rock without soil cover. Small patches contain shallow or very shallow, strongly calcareous, gravely and stony loams. While the soils afford very sparse shrub and grass vegetation offering limited grazing, the rock outcrop only has a water catchment value.

Most water resources in the project area are derived from precipitation (<15 cm per annum) that enables the groundwater recharge < 5 mm per year, which is far below the withdrawal rate. Tube wells are the main source of irrigation, while Karezes are also used as a means of irrigation. Groundwater is available at 60 to 120 feet. The floodwater drains in Southgan

nullah on which the dam is being proposed. Over exploitation of groundwater is continually mining the groundwater in the region to threatening levels. Quality of groundwater is generally good for both irrigation and consumption by livestock and human beings.

The sparse natural vegetation structure in the project area reflects extreme aridity of the climate. The vegetation comprises Acacias, Palms and perennial grasses such as Panicum and Pennisetum. General structure reflects the aridity of the climate and is generally very sparse (10 % cover) to sparse (10 - 20 %) on the surrounding mountain slopes. The area has frequent barren slopes and 10cally narrow-leaved shrubs. The project area has the potential to grow wheat, barley, maize, onion, potato, watermelon, and vegetables as well as fruit trees such as date palm, pomegranate and apricots. Acacias and Prosopis species dominate as the natural vegetation.

CATCHEMENT AREA OF ZARAP NULLAH, DISTRICT PANJGUR:

The proposed study area is located about 2 km southwest of Panjgur town in Panjgur District, which falls under subtropical, continental, hyper-arid, Mediterranean climate. Mean annual temperatures in the area are between 18 ^{0}C and 24 ^{O}C, with rare incidence of frost or snow. Average annual rainfall is below 9.8 inches in some instances falling even below 4.0inches. Aridity is severe in the district and there is usually more rain all in winter than in summer.

Texture of Soil, Landform, Vegetation and water resources.

The study area is part of the Makran Mountain Ranges, which are made up of uniform sequences of Tertiary and Quarternary sedimentary rocks. The Quarternary is represented by continental deposits such as gravely fans, windblown sands and silt sand and very thick brightly coloured, green, white, red, lacustrine clays and silts. The soils have a weakly homogenous porous structure, mainly gravely loams, calcareous with lime contents of about 15%. It has high moisture retention capacity and does not crack or harden. The rock fragments present, in and on the surface, are without signs of weathering. The saline basins also exist in the area, which are gypsiferous, moderately saline and hygroscopic, with local sodicity and pH values of 8.6 -10.0. The surface of the surrounding mountains and hill slopes is bare rock without soil cover. Small patches contains shallow or very shallow, strongly calcareous, gravely and stony loams.

Most water resources in the project area are derived from precipitation (23 cm per annum) that enables the groundwater rechaıge 5 mm per year, which is far below the extraction rate. The major sources of irrigation water in irrigated areas are Kareze and the Kauniro. In-19.93 it was estimated that there are 117 active Karezes and 30 Kaunjros in Panjgur Over exploitation of groundwater in the region is continually mining the groundwater to threatening levels. Quality Jof groundwater is generally good for both irrigation and consumption by livestock and humans.

The study area is part or Central Makran and known ror plant species such as Acacias, Prosopis, date palm, pomegranate and citrus etc. The sparse natural vegetation structure rellects extreme aridity of the climate. The vegetation comprises Acacias, Palms and perennial grasses such as Panicum and Pennisetum. General structure reflects the aridity of the climate and is generally very sparse (less than 10 % covers) to sparse (10-20 %) on the surrounding mountains slopes. The area has frequent barren slopes and locally narrow-leaved shrubs and sparse to moderate tree cover.

CATCHEMENT AREA OF CHOTANG RIVER, DISTRICT KALAT

The proposed study area is located 15 km from RCD road towards northeast in Kalat district. The area falls under temperate, continental and semiarid to arid. Mediterranean climate with mean annual rainfall below 20 cm. Mean annual temperatures are 10 -18 ^{o}C. The area receives snowfall during winter and the temperature drop below freezing point, while summer "temperature varies from 30- 42 ^{o}C. Winter rain showers and snowfall generally have low erosivity, while monsoon rains in the area are highly erosive causing floods in the local streams.

Texture of Soil, Landform, Vegetation and water resources:

The project area is a part of the Kalat District and mostly comprises plain landform surrounded by mountains. The soils in the plain area have a homogenous porous structure, mainly silty and fine-silty, locally clayey, strongly calcareous with 18-20% lime content uniformly- distributed in the profile. The Surface of the surrounding mountains and hill slopes is bare rock without soil cover. Small patches contain shallow or very shallow strongly calcareous, gravely and stony loams. While the soils afford very sparse shrubs and grass vegetation offering limited grazing, the rock outcrop only has a water catchment value.

Most water resources in the project area are derived from precipitation (20 cm per annum) that enables the groundwater recharge 5 mm per year, which is far below the extraction rate. Tube wells are the main source of irrigation. Groundwater is available at 300- 350 feet. The other sources of irrigation in the district are Karezes and springs. The floodwater drains in Chotang River. Over exploitation of ground water in the region is continually mining the ground water to threatening levels. Quality of groundwater is generally suitable for both irrigation and consumption by human beings and livestock.

The sparse natural vegetation structure in the project area reflects aridity of the climate. The vegetation comprises dwarf shrubs, Pistacia trees, prunus eburnean shrub and annttal grasses such as bromus and Aegilopes. Natural vegetation is generally very sparse «10% cover) to sparse (10-20%) on the surrounding mountains slopes. The mountain slopes show the typical steppe(grassland) appearance very sparse dwarf shrubs steppe (grassland) with winter-spring annual grasses and herbs and very sparse cold deciduous broad-leaved relict woods (ash, Patricia)

CATCHEMENT AREA OF KAPIP TANG I NULLAH, DISTRICT ZHOB:

The study area lies with in district Zhob located about 17 miles from Zhob town towards its southeast direction in Kapip Sherani Area.Topographically the area is covered with mountains and hills intersected by the broad valley of Zhob River and its tributaries. The study area falls under temperate, dry, semi-arid to arid, continental climate with mean annual rainfall less than 20 cm. Zhob is characterized by hot and dry summer and cold winter. June is the hottest month with maximum and minimum temperature of about 37 ^{o}C and 23 ^{o}C respectively. January is the coldest month with mean maximum and minimum temperature of about 13 ^{o}C and -1 ^{o}C respectively.

Texture of Soil, Landform, Vegetation and water resources:

The study area comprises mountainous, sub mountainous and plain landforms. The soils in the plain area have a homogenous porous structure, mainly silty and fine-silty, locally clayey, strongly calcareous with 18-20% lime content uniformly distributed in the profile. The Surface

of the surrounding mountains and hill slopes is bare rock without soil cover. Small patches contain shallow or very shallow, strongly calcareous, gravely and stony loams.

Most water resources in the project area are derived from precipitation (25 cm per annum) that enables the groundwater recharge 5 mm per year, which is far below the withdrawal rate. Over exploitation of ground water in the region is continually mining the ground water to threatening levels. Groundwater in the project area is available at 100 -200 feet. Quality of groundwater is generally good far both irrigation and consumption by livestock and human beings. The majority of the area in the Zhob district is irrigated by springs, totaling some 120 in numbers. In the case of large springs the water is led to the land through channels (Walla). In case of small springs, the water is stored in reservoirs and then brought to the land. There are very few Karez systems in Zhob. The major crops grown in the areas are Fodder, fruit trees, wheat maize and some vegetable nuts.

The sparse natural vegetation structure in the project area reflects aridity of the climate. The vegetation includes pines, olives dwarf shrubs and Pistacia trees. Natural vegetation is generally very sparse «10% cover) to sparse (10-20%) on the surrounding mountains slopes. The mountain slopes of the project area show the typical steppe (grassland) appearance; very sparse dwarf shrubs steppe with winter-spring annual grasses and herbs and very sparse cold deciduous broad-leaved relict woods (ash, Pasticia).

Result and Discussion:

In most of the areas of Balochistan having low rainfall and hot climate water is scarce and is put to best use and needs reservation/conservation. The scarcity of water availability restricts the agriculture and other developmental activities in the area. Therefore Delay Action Dams, as already existing in most of the area of the province, have been proposed on the nullah/rivers in the study areas. This integration of natural resources into economic activities will ensure sustainability and acceptability of development. The proposal of Delay Action Dams have got dual purpose construction activities aimed at protection agriculture land and orchard from floods by virtue of their ability to store water and thus reducing the peak discharge of flood flow. Secondary action of the dam is to provide temporary storage to delay the flood, thus helping groundwater recharge which consequently make tubewells and Karezes operational for agriculture. In conjunction with this, harvesting of rainwater measures for improving the management of watersheds are also introduced. No negative impact is attributed to the construction of delay action dams.

The construction of proposed structures will have no significant effect on flora and fauna consisting of natural, semi natural vegetation and wild life/ fisheries as their existing habitat will not be disturbed or altered. Life style of the local inhabitants will also improve due to increased income, improved supply of water for domestic use and for livestock. The reduced soil erosion and reclamation of soil land will increase agriculture input in area close to the flooding stream without fear of damage or complete loss of crops and orchards.

The construction activities are likely to improve socio-economic conditions of the local population without having any significant negative impact on environmental aspects in the subject areas. Initial Environmental Examination (IEE) for the proposed scheme has been carried out for the key environmental impacts arising from the flood control measures and ensure that the activity will result in sustainable physico-ecological and socio-economic development in the areas.

Table 1.0 showing the various features of the Proposed Delay Action Dams

S. No.		Zarap D.A. Dam	Southgan D.A. Dam	Kapip Tangi D. A. Dam	Chotang D. A Dam
I.	River/Nullah, Distt.	Zarap Nullah, Panjgur	Southgan Nullah, Kharam	Saliaza River, Zhob	Chotang River
2.	Catchment Area (sg.mile)	10	38	65	9.9
3.	Max. Discharge (cusecs)	4600	6600	16500	4300
4.	Max. Storage Capacity (acres ft)	1518	12,95	2100	307
5.	Crest length of dam (ft)	1300	1030	2300	710
6.	Max. Height of dam (ft)	36	45	50	36
7.	U/S slope of embankment	2.5: I	2: I	2.5: I	21
8.	D/S slope of embankment	3:1	3:1	3:1	3:1
9.	Top width (ft)	20	20	20	20
10.	Base width (ft)	2i8	265	306	220
11.	Free Board (ft)	7.0	8.0	8.5	10.0

Conclusions:

i. The proposal of Delay Action Dams, though small in size, will help in protection of the area from flood and recharge of water in the various districts of Balochistan.

ii. The activities have little and limited impact on physical biological and socioeconomic Issues.

iii. A complete environmental impact assessment or further special studies for the projects are not required. The ____ does not agree with this observations ____ may be required for each set for small dams , as no large construction activities are taking place and neither resettlement nor land acquisition is involved. There is no other issue of serious concern. The Initial Environmental Examination (IE E) of the proposal reveals overall positive impact of the construction activities on the local environmental conditions.

iv. Table 1.0 reveals that the Maximum Discharge of the stream and the Storage Capacity of the Delay Action Dam are directly dependant on the Catchment Area of the stream/nullah on which the dam structure has been proposed.

Reference:

1. Shaikh I. B. (1998), Research Paper for 681h National Management Course Pakistan Administrative Staff College, Lahore.

2. Hussain Shah (2003), "Evaluation and Study of Drainage System in Selected Areas of NWFP with a Review of Flood Protection Works", Research Work, Deptt. of Civil Engg. U.E.T Peshawar.

3. Abdul Aziz Ismail Kashif (I987) "GROUNDWATER ENGINEERING" McGRAW-HILL.

4. Pumia B.C, January 1984, "Irrigation and Water Power Engineering" Delhi.

5. Ahmad Nazir, 1995, "Ground Water Resources of Pakistan" Shazad Nazir, Gulberg-ill, Lahore.

6. Package-B Consultants Studies for Second Flood Protection Sector Project, PC-Is for Balochistan Area, Federal Flood Commission, Islamabad.

7. Shaikh 1. B. (2001) Efficient & Sustainable Irrigation Management in Pakistan, written for Commission for Science and Technology for Sustainable Development in South Asia (COMSAT), Meeting in Islamabad, Pakistan.

MECHANICAL PROPERTIES OF WELDED DUPLEX STAINLESS STEELS

By

M. Ajmal* and A. Nawaz**

ABSTRACT

In the present study butt groove joint 20-20 mm on duplex stainless steels (UNS S31803) were welded by using Gas Tungsten Arc Welding (GTAW) and Shielded Metal Arc Welding (SMAW).The root of the butt groove joints were welded by using GTAW, the filling and capping were made by using SMAW. The ferrite number and hardness testing were carried out on parent metal, heat affected zone (HAZ) and the welded zone. The tensile testing and impact testing were also carried out on the parent and the welded samples. The mechanical properties of the welded samples show that the procedure for the welding fulfills the requirement for qualification of Welding Procedure Specification (WPS). These welding procedures are used on the above mentioned duplex stainless steels for the up-gradation of Kadanwari gas fields phase II.

Key words: SMAW, GTAW, Duplex stainless steel, Welding, Joints.

INTRODUCTION

Duplex stainless steels are a new generation of stainless steels. It is more often a descriptor of an alloy where both phases i.e. ferrite and austenite are present in significant quantities. Duplex stainless steel covers ferritic/austenitic Fe-Cr-Ni alloys with 30% to 70% ferrite[1]. Due to superior properties of duplex stainless steel with high strength and excellent corrosion resistance[2], this material is used in major oil & gas industries where pitting resistance is of main concern. Other applications include storage and pulp industries etc. The pitting resistance equivalent number of these duplex stainless steels is higher than any other stainless steel grades [2].

Joining of stainless steels is not only an important concern of its different classes but also a major role in their utility at various industries. So welding of duplex stainless steels is an area of interest for many researchers[3] all over the world. Miano well-head, Kadanwari gas fields are the first place in Pakistan where the utility of these steels was evidenced for the last ten years[4]. The welding techniques for the joining of this alloy includes processes like gas tungsten arc (GTAW) and shielded metal arc welding (SMAW) etc. Welding procedure specification for this alloy has been established by Ajmal et al [5].

The procedure adopted for such study is obtained by defect free weldments by the adjustment of welding variables like voltage, current, travel speed & heat input. Further requirement after obtaining the defect free welding is that it must have almost similar mechanical properties as that of the parent metal.

In the present work the mechanical properties of the welded duplex stainless steel UNS-S31803 were studied. For this purpose butt groove joint 20-20mm were welded by WPS established by Ajmal et al[5].

---

*, **Department of Metallurgical and Materials Engineering, University of Engineering and Technology, G.T. Road, Lahore-054890.

EXPERIMENTAL WORK

Duplex stainless steel (S 31803) plates with the following dimensions were used for the present study: 100 mm X 20 mm X 20 mm thick. The composition of this steel along with the Pitting Resistance Equivalent No. [PRE_N] is shown in Table 1.

Two types of welding techniques i.e. Gas Tungsten Arc Welding (GTAW) and Shielded Metal Arc Welding (SMAW) were employed on the welding of butt groove joint 20-20 mm.

Duplex consumable bare electrode wire of 3.2 mm diameter whose composition is available in Table 2 was used for gas tungsten arc welding. Similarly coated electrode rod of diameters 3.2 mm and 4.0 mm were used for shielded metal arc welding and their compositions are also available in Table 2.

In the present study butt groove joint (20-20mm) as shown in Figure 1 was used for the welding of duplex stainless steel plates using duplex consumables. The welding variables used for above mentioned joint by GTAW & SMAW were taken from Ajmal et al[5] work.

Three butt groove joints as shown in Figure 1 were made on the duplex stainless steel plates by wheel disk grinder. The root of the groove joints were welded by 3.2 mm bare rod using GTAW, the filling was carried out by 3.2mm coated electrode and capping were made by using 4.0mm coated electrode using SMAW.

The ferrite scope was used for measuring ferrite numbers from the parent metal as well as the GTA & SMA welded areas of the butt groove joints. The hardness numbers were taken from weld, heat affected zone (HAZ) and parent metal of all the samples by using Vickers hardness tester (Shimadzu Corporation).

Tensile testing was carried out on number of parent and welded samples with a gage length of 50 mm and diameter of 20 mm by using 100 ton universal testing machine (Instron). Impact testing was also carried out on a parent and welded sample with a v-notch by using charpy impact testing machine (Shimadzu Corporation). The welded samples for tensile testing and impact testing were prepared in such a way that each sample contains welded butt groove joint.

RESULTS AND DISCUSSION

Ferrite Number:

The ferrite number of parent metal and weld zone of butt groove joints welded through GTAW and SMAW are shown in Table 3. The measurement was done on the principle of magnetic content of the specimen[6]. The ferrite numbers of welded areas of butt groove joints are in the range of 48-52 whereas the ferrite number of parent duplex metal is in the range of 36-42. This slight increase in the ferrite number of welded area as compared to the parent metal is acceptable[7]. It may be because of slight change in the composition of duplex consumable rods as compared to the parent metal.

Hardness Measurements

Vickers hardness numbers of parent metal, weld metal and HAZ for butt groove joint are shown in table 4. It may be seen from the table that the hardness of parent metal and weld zone are almost similar. This similar hardness number of the parent metal and weld zone indicates that the properties and the microstructure are almost same in the weldments (parent, HAZ & weld zone). It may also be thought that welding do not produce any deleterious impurities in the weld zone as these impurities are the major cause of the increase in hardness number of the weld and HAZ[8].

Mechanical Properties

The mechanical properties i.e. 0.2 % proof stress, ultimate tensile stress (UTS), % elongation and % reduction in area of duplex stainless steel (parent metal) and welded butt groove joint 20-20 mm are shown in Table 5. The acceptable (minimum) mechanical properties [6] for any duplex stainless steels are also shown in Table 5. It can be seen that the proof stress, UTS and % elongation of parent metal and weld zone are almost similar and are well above the acceptable value for the duplex alloys. Therefore mechanical properties for the parent and the welded samples indicate that a sound butt-groove weld joint was obtained. The impact energy for parent metal and welded samples is also shown in Table 5. It can be seen in Table 5 that the impact energy[8] for weld zone is lower than the parent metal but it is higher than the minimum acceptable value i.e. 54 J.

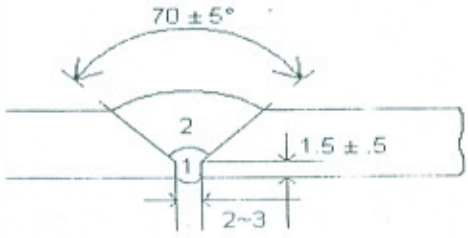


Figure 1: Schematic of duplex butt welded groove joint 20-20 mm.

Elements	C	Mn	P	S	Si	Ni	Cr	Mo	N	PRE_N
% age	0.006	1.83	0.003	0.0007	0.61	5.53	24.46	3.01	0.17	35.1

Table 1: Composition of parent duplex stainless steel metal.

Elements	C	Mn	Si	S	P	Cr	Ni	Mo	Nb	Cu	N	PRE_N
% age* 3.2 mm	0.017	1.27	0.56	0.002	0.02	23.4	8.1	3.14		0.07	0.18	36.6
% age** 3.2 mm	0.022	0.66	0.68	0.011	0.026	22.6	8.2	3.2	0.03	0.08	0.2	36.4
%age*** 4 mm	0.022	0.6	0.71	0.01	0.022	22.7	9.6	3.2	0.016	0.07	0.19	36.4

* 3.2mm diameter bare wire electrode for GTA welding
** 3.2mm diameter coated wire electrode for SMA welding
*** 4mm diameter coated wire electrode for SMA welding

Table 2: Composition of bare wire for GTAW and coated electrode for SMAW

FN Readings	Parent Metal	Weld Zone
1	36	50
2	38	49
3	40	50
4	38	51
5	42	48
6	41	51
7	40	50

Table 3: Ferrite numbers of parent & SMA weld zone of duplex stainless steel.

Hv Readings	Parent Metal	HAZ	Weld Zone
1	291	298	300
2	295	297	303
3	294	299	301
4	292	300	302
5	291	302	304
6	293	303	299

Table 4: Vickers hardness number of parent, weld metal & HAZ of duplex stainless steels.

Mechanical Properties	Minimum values	Parent metal	Welded joint (20-20 mm)
0.2 % Proof stress MPa	450	580	486
UTS MPa	620	745	693
% Elongation	25	34	26
% Reduction in Area	40-45	42	40
Impact strength- J (-40°C/F)	54	212	128

Table 5: Mechanical properties of parent metal and welded butt groove joint 20-20mm of duplex stainless steel.

CONCLUSIONS

1. Ferrite number measurements of welded and heat affected zones are slightly higher than the parent metal. These higher values of ferrite numbers in the welded and HAZ are acceptable for the welding of duplex stainless steels.

2. Vickers hardness number of duplex parent, welded metal and heat affected zones are quite close to each other and show the homogeneity of the welded portion of the parent metal.

3. The mechanical properties of parent metal and welded sample were almost similar. Further more these values are well above the minimum required values for the duplex stainless steel alloy (UNS S31803).

ACKNOWLEDGEMENTS

The authors are thankful to FS Corporation for supply of materials and providing plasma arc cutting facility.

REFERENCES

1. Solomon H.D. & Devine T.M. "Duplex stainless steels-A tale of two phases". Conf. Proc. Duplex stainless steels, ASM, Materials Park, Ohio, 1984.
2. Gunn R.N. PhD Thesis. Imperial College of Science, Technology and Medicine, London. 1997.
3. Gunn R.N. Conf. proc. Recent developments in the joining of stainless steels and high alloys, Columbus, EWI/'TWI/AWS, 1992.
4. Gunn R.N. "Duplex Stainless Steels, microstructures, properties & applications", Abington publishing, Cambridge, England. 1997. Reprinted 2003
5. Ajmal M. & Nawaz A. "Optimization of welding parameters and properties of duplex stainless steel by GTAW & SMAW". 2nd International Conf. on Frontiers of Advance Engineering Materials. PITMAEM, PCSIR Laboratories complex, Lahore. 2006
6. Karlsson L. "Duplex stainless steel weld metals-effect of secondary phases." Conf. proc. Duplex stainless steel. 1997.
7. Kotecki D.J. "Ferrite determination in stainless steel welds-Advances since 1974". Welding journal, vol. 76, No.1. 1997.
8. James D.R. & Ralph M.D. "Critical review of the testing methods applied to duplex stainless steels". Conf. proc. Duplex stainless steel. 1997.

TQM PHILOSOPHY BASED PAKISTAN NATIONAL QUALITY AWARD

Dr Nawar Khan
PhD Engineering Management, MSc Production Engineering,
MBA (HRM), BSc Mechanical Engineering
Professor, College of Electrical & Mechanical Engineering (E&ME)
National University of Sciences & Technology (NUST), Peshawar Road Rawalpindi, Pakistan
Tel # 091-051-561-32627, Fax # 091-051-9278048 E-mail: nwr_khan@yahoo.com

ABSTRACT

This paper describes the main contents of a newly developed Pakistan National Quality Award (PNQA) model which is based on the philosophy of Total Quality Management (TQM) along with some of the similar awards around the world. The main aim of the paper is to highlight the PNQA scored criteria set, framework, categories and schemes for scoring and analysis of application of a company. PNQA is in its early stage of establishment and new categories of companies are expected to be included in future.

The TQM philosophy is claimed to give competitive advantages to companies after a correct implementation approach is followed and it is implemented in full. ISO 9000 Quality Management System (QMS) provide is a stepping stone for TQM implementation. TQM has proved its impact on business performance as noted by researchers and users.

The best known among the existing national and regional quality award models is the Deming Prize of Japan, the Malcolm Baldrige National Quality Award model of United States of America and the European Quality Award model of Central European countries. Winners of these quality awards have claimed positive results of technical, social, economical and moral performance of their businesses irrespective of its sector and scale of economies. Similar impact result is expected from PNQA on industry and economy of the country.

The newly developed PNQA model is at par with the existing national and regional TQM award models. All these National Quality Award (NQA) models are considered to be the best in their own perspective of national priorities and industrial interest.

These NQA models stimulate competition among companies to develop excellent quality products and provide excellent services. Such quality scheme shall also enhance quality awareness, motivation and culture in the workforce and organization. Consequently, NQA shall increase their industrial productivity to raise the level of national exchequer, thus reduces the burden of poverty and debt. PNQA model can meet the requirements of a fiercer open house trade competition unavoidable under the World Trade Organization (WTO) protocols.

Keywords: TQM Philosophy and its Impact, ISO 9000 QMS, National and Regional Quality Award Models, Pakistan National Quality Award model, Assessment Scheme, WTO Protocols

1. INTRODUCTION

The word Total Quality Management (TQM) is considered as a management approach or philosophy of an organization focused on quality, embedded in its business strategy, based on the participation, involvement and commitment of all its members and aimed at long term success through customer satisfaction. TQM philosophy delivers benefits to all associates of the company and to the society at large.

TQM philosophy requires the contributions of every person, at all levels, in every process and from all departments to achieve excellent quality of their products and services, which is

controlled and assured through management guidance. Business in today's competitive environment of open house trade under the World Trade Organization (WTO) protocols is becoming fiercer and challenging. Conducting business of a company in an efficient and effective manner should be the prime aim of its top management and workforce. Desired quality at a competitive lower price will remain the major criteria for continued successes of Pakistani businesses in the local as well as global community.

A quality award model represents the TQM concepts and principles in a scored criteria set along with a framework. Most of the developed and under developing countries around the world have either designed their own model or adopted the models of others as their national quality pride. These TQM models had been used by companies for the purpose of either self assessment or winning a prestigious national quality award. ISO 9000 Quality Management System (QMS) standard is considered as a first step for TQM implementation because this standard contains almost 40 % of the TQM philosophy.

The best known among the existing national and regional TQM philosophy based quality award models is the Deming Prize (DP) of Japan, the Malcolm Baldrige National Quality Award (MBNQA) of USA and the European Quality Award (EQA) of Central European countries. Winners of these quality awards have claimed positive technical, social, moral and economic impact on the performance of their businesses irrespective of its sector and scale of economy.

The newly developed Pakistan National Quality Award (PNQA) model is also based on the philosophy of TQM. The main focus here is to highlight its scored criteria set, framework, factors, items, categories and assessment and scoring scheme. Positive impact of quality awareness, motivation, moral and culture along with technical and social-economic performance of Pakistani businesses is expected from the implementation of PNQA scheme.

PNQA is at par with the existing national or regional quality award models. However, all these National Quality Award (NQA) models can be considered the best in their own perspective of national priorities and industrial interests. These existing NQA models stimulate competition among companies to develop excellent quality products and provide excellent services. It also increases their industrial productivity which boosted their economy to raises the level of national exchequer, thus reduces the burden of poverty and debt.

PNQA model can meets the challenging requirements of a fiercer open house trade competition under the World Trade Organization (WTO) protocols.

2. TQM AS A COMPETITIVE BUSINESS QUALITY PHILOSOPHY

TQM philosophy was considered by some quality experts and gurus as the business quality miracle of the 20th century because of its engulfing and long term effects on all functions of any business. They are also of the opinion that such a mega phenomenon of the 20th century can not be truly represented by a three alphabet acronym of TQM; however, they have not yet suggested any substitute title for the TQM. Assertions of a few quality experts are presented here to exhibit the competitiveness of TQM

Oakland and Porter (1995 p. 31) presented their views on competitiveness of TQM philosophy as "TQM is a comprehensive approach to improve competitiveness, effectiveness and flexibility by planning, organizing and understanding each activity and involving each individual at each level. It is useful for all types of organizations". HO (1995 p. 4) remarked that "TQM is the totally integrated effort for gaining competitive advantage by continuously improving every facet of an organization's activities". Zubair (1996 pp. 12) stated "Total Quality Management is a major phenomenon of this age". Badri et al. (1995 pp. 36) maintained that "quality

management is a key factor in gaining competitive advantages". Motwani (1997 pp. 647) asserted that "TQM is capable of providing a competitive advantage to an organization". Bohoris (1995) has concluded that "successful implementation of TQM was the only way forward for survival in the competitive business world of today and in the future". Evans & Lindsay (2000), in a very concise phrase have said about the importance of TQM for a business as "today, total quality is a matter of survival".

It can be reasonably argued from this small sample of quotations that TQM philosophy is the best way to achieve Competitive Business Position (CBP), both at present and in the future at national and global level by all types of businesses. Also, TQM philosophy has shown a direct impact on the corporate business performance including satisfaction of all its stakeholders (customers, employees, society, shareholders and government). ISO 9000 QMS is considered as a subset of TQM philosophy, so its implementation should also help in the quality awareness, motivation and culture, streamlining of documentation and improvement in quality management practices. As such, ISO 9000 QMS standard certification should be considered as the best way for implementation of TQM philosophy based PNQA.

3. TQM PHILOSPHY BASED ASSESSMENT MODELS

Countries and even some regional blocks of the world have developed the TQM assessment award models according to their national priorities and specific industrial use. Mostly, the existing award models are named either after their country name, regional block or the quality proponent in that country. However, there is no universal TQM award model, which is acceptable to all the nations of the world (Nawar, 1999).

Assessment models are used either for self appraisal of a business to find strong and weak areas of TQM practices or winning a prestigious TQM award through competition in its respective category. It checks; how the TQM factors and items were approached, implemented and what results were achieved. Assessment models were either developed or used by quality experts, like Wiele et al. (1996 pp. 93); Hakes (1996 p.24) and Zia ul Haq (1996 pp. 62, 63).

A sample list of existing major TQM assessment models is presented in Table 1. The main aim is to highlight that the assessment models are used in most countries of the world (Wiele et al., 1996 pp. 93; Ghobadian & Woo, 1993; Ghobadian & Woo, 1996; EFQM, 1997; JUSE, 1996; Laszlo, 1997; Puay et al., 1998; Nawar & Rehman, 1996-1997; Kakkar, 1996; Bohoris, 1995; NIST, 1998 and BQF, 1998).

Table-1: National Quality Assessment Models

• Australian Quality Award	• Japan Medal (Japan)
• Brazilian National Quality Award	• Netherlands Quality Award
• Canadian Award For Excellence	• New Zealand National Quality Award
• Deming Prize (Japan)	• Phillips Crosby Quality Award
• European Quality Award	• Scotland Quality Award
• French Quality Award	• Swedish Quality Award
• Irish Quality Award	• Singapore Quality Award
• Malcolm Baldrige National Quality Award (USA)	• The Northern Ireland Quality Award
	• UK Quality Award

4. THE BEST KNOWN TQM AWARD MODELS

The most widely used and best known TQM assessment awards models among the existing ones are; the DP, MBNQA and EQA (Jones, 1995; Bohoris, 1995; Ghobadian & Woo, 1996 and Nawar, August 1999). Most of the other quality awards are either not very

comprehensive or are derived from these best known quality award models. However, any NQA based on TQM philosophy is expected to generate a momentum of continuous quality improvement in any organization around the world, irrespective of its size and type of business.

4.1 The Deming Prize (DP)

Union of Japanese Scientist and Engineers (JUSE) was the first to formulate the TQM concepts in a synthesized form in 1951 as DP (see more details on website www.juse.or.jp). The prestigious DP was named after the American statistician, Dr W.E Deming, who taught Japanese the Statistical Quality Control (SQC) techniques to improve the quality of their products and services after the 2nd World War. JUSE is responsible for technical and administrative affairs of the DP. The criteria set and framework of DP model is revised as and when required.

4.2 The Malcolm Baldrige National Quality Award (MBNQA)

In 1987, the next famous TQM award came from United States of America (USA), called MBNQA (see more details on website www.quality.nist.gov). This TQM based award was named after the American Minister of Commerce, a proponent of quality in the USA. MBNQA is administered by American Society for Quality (ASQ) and National Institution of Standards and Technology (NIST) of America. The criteria set and framework of MBNQA model is revised on annual basis.

4.3 The European Quality Award (EQA)

In 1993, the central European countries collectively evolved their regional TQM based award model, called as EQA (see more details on website www.efqm.org). These countries do have their national quality award models as well. EQA is administered by European Foundation for Quality Management (EFQM). The criteria set and framework of EQA model is revised on annual basis.

5. PAKISTAN NATIONAL QUALITY AWARD (PNQA)

The latest addition in TQM based award models is PNQA (see more details on website www.npo.gov.pk). PNQA symbolizes the 'Made in Pakistan' commitment of 'Quality Excellence' for its products and services and productivity. PNQA is passing through its dynamic phase of establishment. New categories of companies will be included in its scheme in future. Also, its criteria set and framework will be reviewed annually to improve it. National Productivity Organization (NPO) of Ministry of Industry, Production and Special Initiatives is the custodian of this prestigious NQA.

Annual assessment of companies and award ceremony of PNQA winners is expected in the year 2007. PNQA aims at satisfaction of all its stakeholders, including customers, employees, management, shareholders and government through workforce competency, increased productivity and innovation, low cost and excellent quality by eliminating waste in all forms. PNQA will also encourage, develop and promote quality awareness and culture among all the stakeholders and associates of a company.

5.1 Award Management

The PNQA scheme will be managed by a comprehensive organizational structure as shown in Figure 1.

- Governing Council
- NPO of Ministry of Industries, Production and Special Initiatives
- Board of Overseers
- Panel of Assessors



Figure 1: Organization Structure of PNQA Scheme

5.2 Assessment Process

A team of PNQA national assessors will evaluate each application report before their evaluation is reviewed by the board of overseers. Short listed applicants will be granted site visits. Based on the review of the application and the results of the site visit, appropriate recommendations of award recipients will be made to the Governing Council for approval. Decisions by the Governing Council are final and indisputable.

5.2.2 Anticipate Assessment and Feedback

A well-written response is one that gives clear information on the approach and its deployment. Subjective information or incomplete information should not be included application as it is not possible for the PNQA national assessors to prepare meaningful feedback report based on such information. Practices used should illustrate clearly how the approach mentioned in the response is executed. All responses should be concise and factual. Statements should be supported with data wherever appropriate.

5.2.5 Application Review

Applications will be reviewed and evaluated by members of the Panel of Assessors in a four stage process as shown in Figure 2.

Stage 1: Independent review and evaluation by at least five members of the board

Stage 2: Consensus review and evaluation for applications that score well in stage 1.

Stage 3: Site visits to applicants that score well in stage 2.

Stage 4: Judges review and recommendations

Panel members will be assigned applications according to the nature of the applicants businesses and the expertise of the examiners. Assignments will be made in accordance with strict rules regarding conflict of interest. Feedback report will be issue at each stage, if a company fails to move over to the subsequent stage.

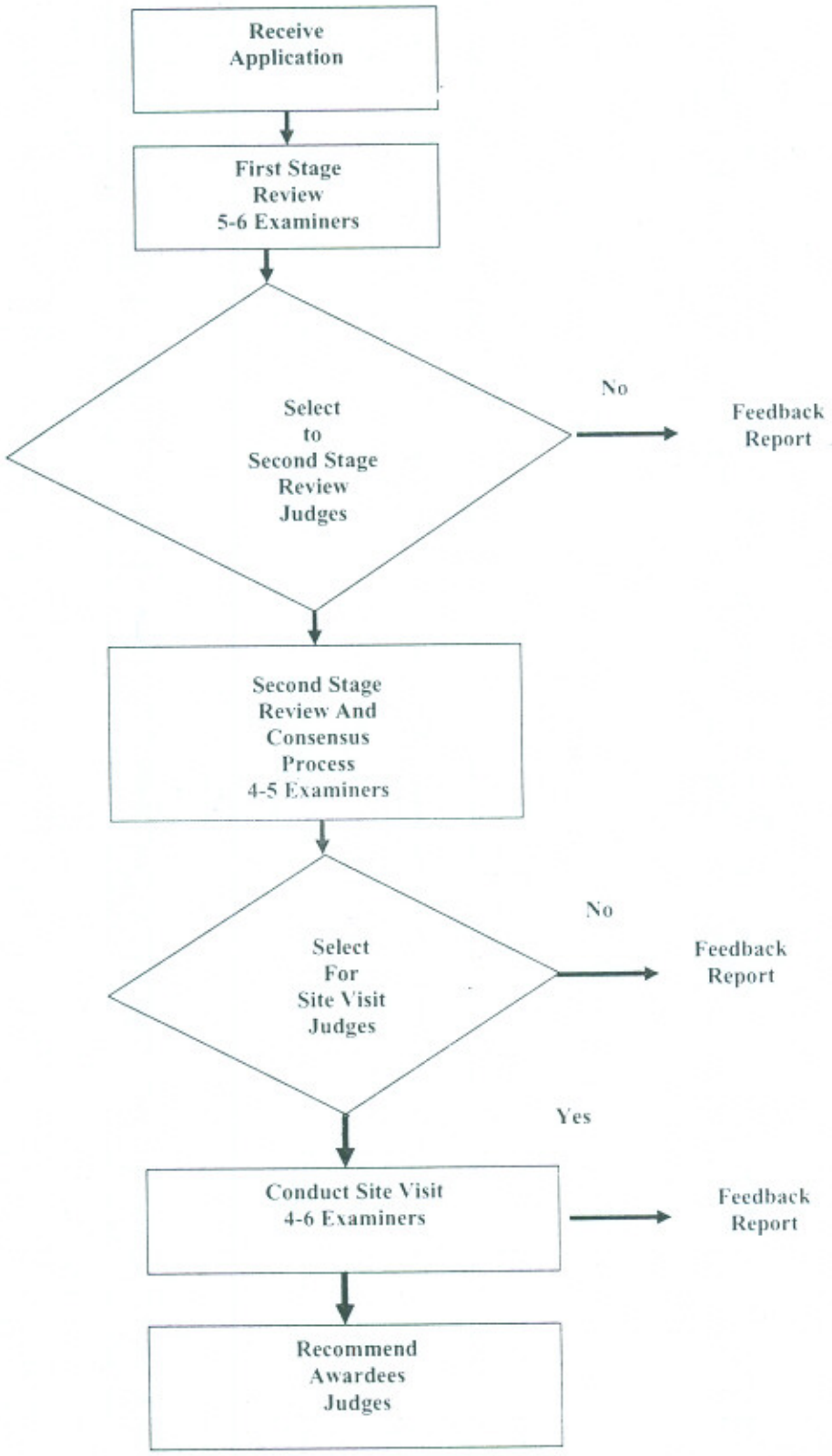


Figure 2: Application Review Process

5.3 Core Values and Concepts

The basic principles on which the PNQA model is built are shown in Table 2.

Table-2: Core Values and Concepts of PNQA Model

1. Customer Driven Quality 2. Leadership 3. Continuous Improvement and Learning 4. Employee Participation and Development 5. Fast Response	6. Design Quality and Prevention 7. Long Range View of the Future 8. Management by Fact 9. Partnership Development 10. Corporate Responsibility and Citizenship 11. Result Orientation

5.4 Criteria Set for Quality Excellence of PNQA Model

The state of quality excellence can be achieved by any company through application of criteria set of PNQA model. This criteria set will be reviewed annually through a technical committee with members from all walk of life and industries. New concepts may be added or existing concepts may be deleted or modified and its weightage may also be changed, if required. The summary of scored criteria set of PNQA model is shown in Table 3 and its detailed items are shown in Table 4.

Table-3: Summarized Scored Criteria set of PNQA Model

S. No	Main Factors	Weightage (%)	Marks
1	Top Management Leadership and Management of Quality	17	170
2	Use of Quality Data and Information	10	100
3	Human Resource Management	15	150
4	Customer Focus and Satisfaction	10	100
5	Quality Assurance of External Suppliers	10	100
6	Process Management	10	100
7	Business Results	28	280
Total		**100**	**1000**

Table-4: Detailed Scores Criteria Set of PNQA Model

S. No	Main Factors	Items	Weighted Score (%)	Equivalent Marks
1.	**Top Management Leadership and Management of Quality**		17	170
1.1		Senior Executive Leadership	2	20
1.2		Leadership System and Organization	12	120
1.3		Public Responsibility and Corporate Citizen	3	30
2	**Use of Quality Data and Information**		10	100

2.1		Type of Data and Information Usage	6	60
2.2		Competitive Comparison and Benchmarking	2	20
2.3		Analysis and Use of Company Level Data	2	20
3	**Human Resource Management**		15	150
3.1		Training Budget and Planning	3	30
3.2		Employee's Well-Being and Satisfaction / Employee Career Plan	3	30
3.3		Employee Education, Training and Development	3	30
3.4		Employee Involvement	6	60
4	**Customer Focus and Satisfaction**		15	150
4.1		Customer and Market Knowledge	5	50
4.2		Customer Relationship Management	5	50
4.3		Customer Satisfaction Determination	2	20
4.4		Customer Satisfaction Results	2	20
4.5		Customer Satisfaction Comparison	1	10
5	**Quality Assurance of External Suppliers**		10	100
6	**Process Management**		10	100
6.1		Research and Development and Process Design	5	50
6.2		Production and Delivery Process	4	40
6.3		Process Management: Support services	1	10
7	**Business Results**		28	280
7.1		Product and Service Quality Results	8	80
7.2		Company Operational and Financial Results	20	200
Total Score			**100**	**1000**

5.5 Framework of PNQA Model

The framework of PNQA model is shown in Figure 3. This framework shows the relationship between different factors of the PNQA model. There are three major areas or blocks in the framework namely the 'Driver', 'System' and 'Results'. The **'Driver'** block represents the 'Visionary Head' of a company, who performs the top management roles of leadership, future focus and provide the driving force through human resource involvement and participation. The **'System'** block is mainly related to transformation, execution and assurance of the top management's visions. Continuous quality improvement in all the processes and activities in a company is the most powerful and evolving concept of TQM philosophy. The **'Results'** block represents the outcome of the system, which include the 'Customer Satisfaction' and 'Business Results' of a company business. The flow of information is shown by arrows which act as the life blood of a company's business.

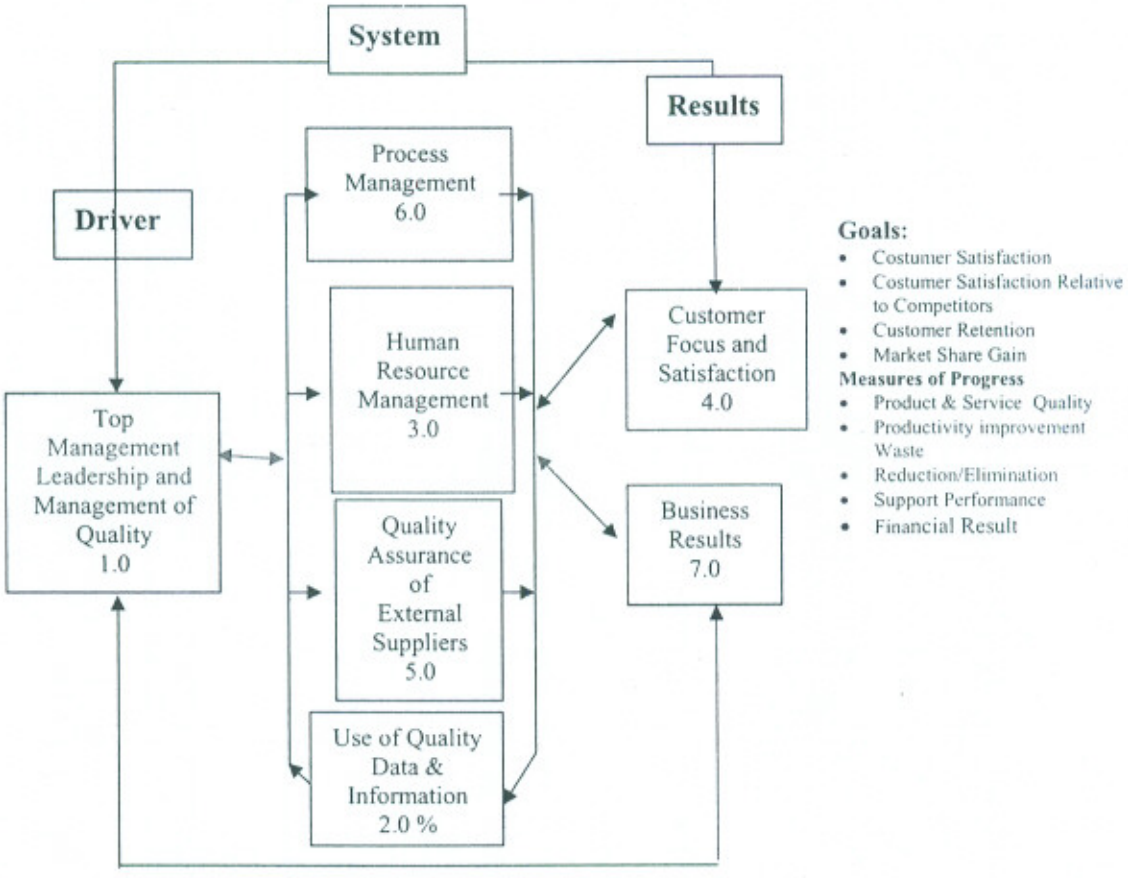


Figure-3: Framework of PNQA Model

5.6 Categories of Businesses. To start the PNQA scheme, the following categories of businesses are considered for award competition at present. This limit is due to shortage of expertise and practices of the new scheme. However, in future, other businesses will also be included in award competition after successful initial run of the PNQA scheme.

- **Manufacturing Companies.** Companies or subsidiaries that produce and sell manufactured products or manufacturing processes or those companies that produce agricultural, mining, or construction products.
- **Service Organizations.** Companies or subsidiaries that offer / sell services.
- **Small Businesses.** A small business is considered to be a complete business with not more than 500 full time employees. Business activities may include manufacturing and or services. A small business must be able to document that it function independently of any other businesses, which are equity owners.
- **Health Care Organizations.** Organizations offering health services like hospitals, pharmacies etc.

5.7 Requirements of an Item of a Factor of PNQA Model

Each factor of the PNQA model contains a number of items as already shown in Table 4. The assessment of each item of a factor is carried out in order to investigate how TQM philosophy have been approached and applied and what results have been achieved that show company lead to a Competitive Business Position (CBP). The assessment requires a company to provide evidence for confirmation and verification of existence of TQM practices. Evidence required for only one item is shown in Annexure 'A' at the end of paper.

5.8 Assessment of a Company

Assessment of a company either for self appraisal or winning a TQM award competition is carried out in two phases as follows.

- Desk audit of the application received from a company by a panel of assessors.
- Site visits to only those companies which have qualified the minimum score (50%) requirements in desk audit to confirm / verify the TQM practices as well.

5.9 Guidelines for Assessment Scoring and Analysis of Company Application

This section describes the scoring guidelines and process of analysis used for assessment of application submitted by a company which is based on the PNQA criteria set.

- **Scoring Guidelines**

  The scores obtained shall be in response to the PNQA criteria set and based on the following three areas:

  - **Approach**

    This describes the methods used by the applicant to address the areas of an item of a factor of criteria set.
  - **Deployment**

    This means the extent to which the approach / method was applied to all the requirements of an item of a factor of criteria set.
  - **Results**

    This means the outcomes in achieving the purpose given in the item of a factor of criteria set.

The scoring guidelines for 'Approach', 'Deployment' and 'Result' are shown in the following Table 5.

Table-5: Scoring Guideline for Approach, Deployment and Results

Score %	Evaluation Dimensions		
	Approach	**Deployment**	**Results**
0-19	>Some form of approach exists but it is reactive and not systematic	>Approach is deployed to few functional / operational areas of the organization	>Poor results >Improvement trends and/or good performance levels in few areas of importance to the organization >Results not reported for most areas of importance to the organization
20-39	>Direction for approach is defined >Beginning of a planned and prevention-based approach	>Approach is deployed to some major functional/ operational areas of the organization	>Improvement trends and/or good performance levels in some major areas of importance to the organization >Early stages of obtaining comparative information >Result reported for most areas of importance to the organization
40-59	>A sound, effective approach is in place with evidence of prevention activities > Approach is aligned with basic organizational needs identified in other criteria categories	>Approach is deployed to most major functional/operational areas of organization	>Improvement trends and/or current performance levels are good in most major areas of importance to the organization >Favorable comparisons with external organizations and/or benchmarks in some areas > Results address most key customer, market and process requirements
60-79	>A proven and well-defined approach which is prevention-based with evidence of refinement through learning and improvement >Approach well-integrated with organizational needs identified in other criteria categories	>Approach is deployed to all major functional/operational areas of the organization > Practiced consistently by all levels	>Current performance levels are good to excellent in all major areas of importance to the organization >Improvement trends are sustained in most areas >Favorable comparisons with external organization and/or benchmarks in key areas >Results address key customer, market and process requirements

80-100	>Exceptionally well-defined, innovative approach >Approach is accepted as best practice in the field >Approach is fully integrated with organizational needs identified in other criteria categories	>Approach is deployed to all functional/operational areas within and outside the organization >Practiced consistently by all levels	>Current performance levels are excellent in most areas of importance to the organization >Excellent improvement trends and/or excellent sustained improvement in most areas >Excellent comparisons with external organizations and or benchmarks in most areas >Results fully address all customer, market and process requirements

5.10 Analysis Guidelines

Desk analysis of the application is carried out and site visits are conducted to confirm or verify the TQM practices. Analysis can be sequenced as follows (Nawar, 1999).

- Strengths (+)
- Weaknesses (-)
- Site Visits Issues (?)

The score achieved (range in %) by each item of every factor of the PNQA criteria set should be recorded. The analysis of only one factor is shown in Table 6 due to voluminous size and space limitation. A feedback report based on such analysis is forwarded to the company for the purpose of improvements.

Table-6: Analysis of PNQA Factors and Items

S. NO	PNQA Factors and Items (Score Achieved)	Analysis		
4.	CUSTOMER FOCUS AND SATISFACTION			
4.1	Customer and Market Knowledge (%)	Strengths (+)	Weaknesses (-)	Site Visits Issues (?)
4.2	Customer Relationship Management (%)	Strengths (+)	Weaknesses (-)	Site Visits Issues (?)
4.3	Customer Satisfaction Determination (%)	Strengths (+)	Weaknesses (-)	Site Visits Issues (?)
4.4	Customer Satisfaction Results (%)	Strengths (+)	Weaknesses (-)	Site Visits Issues (?)
4.5	Customer Satisfaction Comparison (%)	Strengths (+)	Weaknesses (-)	Site Visits Issues (?)

6. BENEFITS OF THE PNQA MODEL

PNQA scheme will inject a quality motivation, promotion and culture in the workforce and companies of Pakistani industry and society at large as evident from NQA practices in other parts of the world. A healthy quality competition will raise the quality standard of its products

and services besides increasing. Such practices will eliminate waste in all forms, thus increases productivity. Even if an award is not achieved, the examination process and its feedback report will provide great valuable inputs and confidence in the company to improve its TQM practices and encourage a corporate quality culture.

The winner companies have to share their best practices in the annual award ceremony so that other companies can benefit from it. The winner companies can use the prestigious PNQA monogram on their letterheads for promotion of its business and gain more of market shares than non award holders. Higher quality at lower price with a large market share will benefit the company as well as customers and society at large. The PNQA scheme provides a win – win situation for every one. The PNQA scheme should also lead to high quality products / services and increased exports that will result in raising the profit level of a company and ultimately the national exchequer. Last but not the least is the quality awareness, mindedness, motivation and culture which will be generated as a result of such a scheme and its continuous practices.

7. CONCLUSION

TQM can be safely claimed as a competitive business quality philosophy. Its implementation has shown a positive impact on the competitive business position of its implemented company. This fact is evident from the analysis of experiences of a number of users and researchers around the world. ISO 9000 QMS can be used as start point for implementation of TQM philosophy.

A number of national quality assessment award models exist around the world. The best known among the existing TQM models are the Deming Prize, Malcolm Baldrige National Quality Award Model and European Quality Award model. The latest addition in the list is Pakistan National Quality Award. The scored criteria set, framework, assessment approach and analysis technique of this model are presented here. Changes for improvement in PNQA scheme is an inbuilt phenomenon. New categories of businesses will be included in the award competition in future.

All these TQM award models accommodate the priorities of factors and items (% weightage, marks and placement in the model) periodically and even add or subtract new concepts in accordance with government policy or industrial needs of that nation. Such changes keep these quality award models more dynamic and flexible to meet the present and future requirements of a fiercer open trade competition under the WTO protocols.

These quality awards generate competition among companies to develop excellent quality products and services. The same is expected from PNQA in our industry and society. Thus, enhancing industrial and national productivity and also increases the margin of profit which will contribute to the national exchequer as well.

ANNEX 'A'

EVIDENCE REQUIRED FOR ASSESSMENT OF AN ITEM OF PNQA MODEL

Factor / category- 3: Human Resource Management (150 Points)

"The human Resource Management category examines how; the workforce is enabled to develop and utilize its full potential, how it has aligned with the company's performance objectives. Also, examined are the company's efforts to build and maintain an environment conducive to performance excellence, full participation and personal and organizational growth".