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Factors associated to non-adherence in Tuberculosis treatment, Baringo County, Kenya

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ABSTRACT

The study was to determine the factors associated to non-adherence to TB treatment at individual, health care provider, facility and community levels.

A cross sectional descriptive survey study was conducted in Baringo County (urban and rural areas), Kenya. Data collection was done using developed self-administered questionnaire and interview schedules and checklist. Respondents were be traced through TB patient defaulters registers and health workers. Convenience sampling was employed. Data was analysed using SPSS version 20.

The study found that non adherence to treatment was both at treatment phases as; intensive (46%) and continuation (54%). Amongst the smoking patients 45% associate it with non-adherence, 58% associated their drinking habit with non-adherence. 53% of patients who walk, 41% of defaulters associated symptoms relieve during treatment with non-adherence, 52% associated their non-adherence with their forgetfulness or carelessness. Defaulting was associated with both patient, health care delivery patterns and socio-cultural factors.

Keywords: *non adherence, treatment interrupters*, *non-adherence factors*

CHAPTER ONE: INTRODUCTION

1.0: Introduction

This chapter in detail discusses the study background; statement of the problem, study objectives, research questions and justification of the study. The study's purpose was to determine the factors associated to non-adherence to Tuberculosis treatment among Tuberculosis patients at individual, health care provider, facility and community levels within Baringo County.

1.1: Background information of the study

Tuberculosis (TB) continues to be a major cause of high morbidity and mortality in Kenya. Kenya is among the 22 countries contributing 80% of global TB burden. The country has improved from number 13th to 15th among the 22 countries. The Kenya TB treatment defaulter rate is 15%. (GLOBAL TUBERCULOSIS REPORT 2013, 2013).

Adherence to TB treatment is one of the factors that lead to increase in cure rate. This reduces mortality and emergence of multi drug resistant tuberculosis (MDR) and lowers the high cost of treatment resulting. Tuberculosis does not discriminate on age, sex or education level. Previous research in different contexts has shown that there exist many factors influencing non compliance. They range from individual patient, health care provider, health care delivery patterns and socio-economic related factors influencing non adherence to TB treatment (Munro SA, et al (2007).

Tuberculosis (TB) is a major contributor to the global burden of disease. Poor adherence to treatment is common despite various interventions aimed at improving treatment completion. Currently, posed is a challenge of non-adherence to treatment despite efforts with patient centred approach which allows home-based treatment supervised by a treatment supporter of their own choice, and health facility–based treatment observed by a health professional.

Lack of a comprehensive and holistic understanding of local and community based barriers can be a hindrance to achieving success in STOP TB interventions. New infections, TB drug resistance, high treatments costs and mortalities have been associated with non-adherence. The aim of the study was to explore the issues surrounding the Tuberculosis patients in order to determine the factors associated with their non-adherence at various levels; this was done at individual (patient), health care provider, facility and community.

1.2: Statement of the Problem

In the management of Tuberculosis (TB), treatment adherence leads to successful cure rate. It's expected that if successful treatment of tuberculosis is to be achieved the patient must comply by taking anti-tuberculosis drugs for at least six months. Non adherence to tuberculosis treatment leads to high increase in mortality, Multi drug resistant tuberculosis (MDR) cases and high cost of TB treatment. These increase the Tuberculosis burden to the nation, partners and community populations. Various Studies have been done to identify factors influencing non adherence in other settings. Factors may differ depending on unique population settings and its characteristics: cultural practices, lifestyle, and economic status among others. It's unclear which factors locally are associated to Tuberculosis patients' non adherence in Baringo County community, Kenya. Baringo County has Low Case notification rate, Low treatment success (<88%), high poverty prevalence (National strategic Plan and Tuberculosis, Leprosy and Lung Health, 2015-2018). If no efforts are put to determine the factors locally influencing non adherence, the STOP TB programs will continue using strategies that are standardized, which might not yield effective results as per the context. Also the local and national

Tuberculosis burden will be on the increase in terms of Multi-Drug Resistance (MDR), mortality and treatment cost.

1.3: Study Objectives

1.3.1: Broad objectives

The study aimed to determine the factors associated to non-adherence of medication among TB patients at both urban and rural areas of Baringo County.

1.3.2: Specific objectives

1. Determine the patient factors which contribute to non adherence of TB treatment
2. Determine the health provider-patient relationships both at the TB clinic and at home
3. Determine the pattern of health care delivery influencing non adherence of TB treatment
4. Determine the socio-cultural factors influencing the non adherence to TB treatment

1.4: Research questions

1. What are the patient-related factors that contribute to non adherence to TB treatment?
2. What are patient-health workers factors in effecting TB treatment adherence issues?
3. What are the health care deliveries Patterns that influence non adherence of TB treatment?
4. What are the socio-cultural factors that influence non adherence to TB treatment?

1.5: Justification

Kenya is among the 22 countries that are contributing to 80% of global TB burden. Kenya is globally recognized as a **pathfinder for TB and leprosy control**. Within Africa, Kenya was the first country to achieve World Health Organization (WHO) targets for case detection and treatment success of new smear-positive pulmonary TB cases. Devolution presents opportunities for local prioritization and adaptation of TB and leprosy control activities that are targeted and patient-centred (National strategic Plan and Tuberculosis, Leprosy and Lung Health, 2015-2018). The non adherence among TB patients has contributed to high rate of new cases, TB related mortality, Multi drug Resistant Tuberculosis (MDR) cases, and treatment costs.

The impact targets for National strategic Plan and Tuberculosis, Leprosy and Lung Health, 2015-2018 at the end of 5 years are:

1. Reduce the incidence of TB by 5%, compared to 2014
   i. Reduce the prevalence of MDR-TB among new patients by 15%
   ii. Reduce the incidence of TB among PLHIV by 60%
2. Reduce **mortality** due to TB by 3%
3. Reduce the proportion of affected families who face **catastrophic costs** due to TB, Leprosy and lung diseases
4. Reduce by 50%, the proportion of cases with **grade 2 disability** due to leprosy
5. Reduce **mortality** due to chronic lung diseases e.g. COPD, asthma

Baringo County's contribution is thwarted by the high default rate and current situation of Low Case notification rate, Low treatment success (<88%) and High poverty prevalence. Non adherence to TB treatment is among major hindrances to the achievement of the priorities for 2015-2018 period to ensure treatment

success rate of at least 90% nationally among all drug-susceptible (DS) forms of TB centred (National strategic Plan and Tuberculosis, Leprosy and Lung Health, 2015-2018).

The purpose of this study was to determine the various factors that are associated to defaulting of TB patient during treatment comprising both urban and rural areas of Baringo County. The study has given recommendations for possible future tuberculosis treatment and management interventions within Baringo and other similar counties. This is within the Ministry of Health *"A nation free from preventable diseases and ill health through primary healthcare interventions at individual, household, community and primary healthcare facility levels"*

CHAPTER TWO: LITERATURE REVIEW

2.0: Introduction

This chapter discusses the various reviewed studies in relation to tuberculosis treatment and the various factors that are associated to defaulting in various contexts.

2.1: Literature Review

Kenya is among the 11 High Burden Countries (HBCs) that are not on track to reaching one or more of the three targets for reductions in incidence, prevalence and mortality (GLOBAL TUBERCULOSIS REPORT 2013 www.who.int/tb/data). Studies have been done at various contexts determining the factors influencing non adherence of tuberculosis treatment. Mohamed et al. (2013) found that existence of human resource gaps and TB staff inadequately prepared to deal with complex issues of TB patients influence the non adherence. They concluded that reducing travelling and waiting times for TB patients may improve compliance rates.

Bagoes et al. (2009) also found that more patients take TB treatment according to prescription if they are clearly informed and costs for treatment are reduced. They concluded that non adherence is a result of developed negative image towards the health care staff, treatment, and quality of medication. Munro et al., 2007 indicated in their study that 'patients and providers' personal character, abuse of substance, and religion influence treatment adherence. Female patients adhered most despite cultural practice of seeking permission for treatment from their spouses'.

Sathiakumar et al. (2010) reported that other non adherence issues besides smoking and travel-related concerns, number of household members, tobacco chewing, and treatment period, relief of symptoms, alcohol consumption and lack of adequate drugs. Also study indicates that 16% non-compliance rate was due to factors like place of residence, literacy, travelling time, waiting time, employment, living status, family support, stigma, khat chewing and patients' knowledge of TB.

Culqui (2012) found that patients' compliance is associated with patient sex usually male, treatment experience especially feeling malaise, or past history of previous non-compliance, use of recreational drugs, dissatisfaction with the information received and presence of poverty. "This Tuberculosis is known to have a strong association with poverty" (National strategic Plan and Tuberculosis, Leprosy and Lung Health, 2015-2018).

Muture et al indicated that most frequent reasons for default cited by patients who did not complete the treatment course included ignorance about need for treatment compliance coupled with inadequate knowledge

about TB and travelling outside treatment areas, consequently missing clinic appointment and running out of drugs. Predictive factors for default were inadequate knowledge about TB, herbal medication use, low income, alcohol abuse, previous default, HIV co-infection and the male sex.

CHAPTER THREE: METHODOLOGY

3.0: Introduction

This chapter discusses the research methodology including study area, population, design, sample size, sample frame and sampling technique, Data collection tools and procedures for data collection, : Inclusion and exclusion criteria, Proposal Ethical approval and Data handling and analysis

3.1: Study Area

The study was conducted in Baringo County, covering both urban and rural areas of the county. Baringo County neighbours Nakuru, Keiyo, West Pokot, Kericho and Laikipia counties. It has attractive tourist Lakes of Bogoria and Baringo. The community is majority of nomads. Interviews were done at four centres; Kabarnet, Marigat, Mogotio, and Ravine.

3.2: Study Population

The study population was all enrolled tuberculosis patients in Baringo county health facilities. All registered and traced TB drug interrupter patients within the six months prior to commencement date of the study were interviewed.

3.3: Study Design

The study utilized a retrospective cohort (drug interrupters) with a mixed method approach comprising both interviews and focus group discussions. Interviews was done to all traced treatment interrupters and a focus group discussion by the Sub county tuberculosis and leprosy coordinators and community health Volunteers.

3.4: Sample size

Treatment interrupter patients were accessed through convenience sampling method, this were Treatment interrupter/defaulters within six months prior to commencement date of the study. One focus group discussion was done comprising 1 County Tuberculosis and Leprosy Coordinator, 6 Sub County Tuberculosis and Leprosy Coordinators and 6 Community Health Volunteers.

3.5: Sample frame and sampling technique

Traced treatment interrupters (defaulters) conveniently selected from hospital records in urban and rural health facilities were interviewed. The treatment interrupters were reached through the assistance of Sub County Tuberculosis and Leprosy Coordinators and 6 Community Health Volunteers. Interviews were conducted using structured and semi-structured interview schedule. In addition Key informant focus group discussion was done with community health volunteers, County Tuberculosis and Leprosy Coordinator and Sub county Tuberculosis coordinators.

3.5: Data collection tools and procedures for data collection

Data was collected using developed observation checklists, interview schedule and questions for focus group discussion questions. Respondents were traced treatment interrupters, health workers (SCTLCs) and Community health volunteers.

3.6: Inclusion and exclusion criteria

All registered and traced treatment interrupters were recruited for study. Transfers in and out were not considered.

3.7: Proposal Ethical approval

The study was submitted to Egerton University Research Ethics committee for ethical consideration and approval. Incentives were given to respondents as compensation for waiting time and inconveniences caused (Fare and lunch).

3.8: Data handling and analysis

All data captured was coded, entered and analysed using SPSS package version 20.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0: Introduction

This chapter discusses the study results as per the analysis of data captured from the treatment interrupters (defaulters) who were traced within the last six months prior to commencement date of the study and outcomes of informant focus group discussion.

4.1: Characteristics of study Sample

The study conducted interview to a total of 46 drug interrupters across Baringo County spread over its sub counties (coverage sub counties of Kabarnet, Marigat, Mogotio and koibatek).

The interviewee's (defaulters) mean age was 36 years with range 51 years (11 to 62). Among interviewee (defaulters) were male 33(72%) and 13(28%) female. In addition were 13 members Key informant who participated in focus group discussion (1 CTLC, 6 SCTLCs and 6 CHVs).

The interviewee's marital status was; Single (35%), Married (54%) and separated (11%). Their education levels were; none (9%), Primary (59%), Secondary (24%) and Tertiary (9%). The interviewee's monthly income levels were; less KSH 3500/(63%), 3500/= to 5000/=(17%), 5000/= to 10000/=(9%), 10000/= and above(11%).

4.2: *What are the patient-related factors that contribute to non-adherence to TB treatment?*

Treatment non adherence was both at treatment phases as; intensive (46%) and continuation (54%). Among defaulters 24% smoke and 76% don't smoke. But amongst the smoking patients 45% associate it with non adherence while 55% don't associate smoking with non adherence. Also among defaulters 41% drink, 59% don't drink. Among those who drink 58% associated their drinking habit with non-adherence.

Defaulters to access health facilities used various means of transport as; walking 26%, Vehicle 54% and Motor Bike 20%. In relation to use of various means to access the clinics; 53% of patients who walk, 86% of vehicles(matatu)users, while 55% of the motorbike users felt that financial challenges would hinder them from attending the clinic.

Only 41% of defaulters associated symptoms relieve during treatment with non-adherence. Defaulter patients' housing during treatments was; Own house (43%), Rental (33%), and with Parents (20%). Among the

defaulter patients 82% understood that they were suffering from Tuberculosis disease, and 94% felt Tuberculosis disease was curable. Only 33% of defaulter patients had a history of never complying with previous medication of other disease during TB treatment. While taking the tuberculosis medication 56% of defaulter patients experienced drug side effects. Among defaulter patients 76% had experienced other sickness during tuberculosis treatment.

Defaulter patients associated their occupation to non-adherence at 41%, while among the casuals workers 85% directly associated it with their non adherence.

Among the TB defaulters 52% associated their non-adherence to their forgetfulness or carelessness.

4.3: What are patient-health workers factors in effecting TB treatment adherence issues?

In seeking clarification for more detailed explanation on TB treatment 80% of TB non-adherents were comfortable asking health provider's questions. Still 52% associated their non-adherence with their forgetfulness and carelessness. Among the TB defaulters 58% associated non adherence to the stressful events experienced during treatment.

4.4: What are the health care deliveries Patterns that influence non adherence of TB treatment?

Support of defaulter during treatment was by; family (56%), Community health worker (2%), Health worker (20%) and none (22%). Family support was experienced to all despite whom they lived with. Health workers support was ranging 22% to 27%. TB defaulters lived with a distance of 46 %(less 10km), 22 %(11km to 20km), 7 %(21km to 30km) and 26 %(above 40km) away from the health facility. Most (59%) treatment interruption was done among TB defaulters with primary level of education

4.5: What are the socio-cultural factors that influence non adherence to TB treatment?

The study found several socio economic factors ranging from: initiation ceremonies for example circumcision exclusion, Believe that TB is witchcraft and inherited in some families, Believe in the effectiveness of injection over oral drugs of 6-8 months, Migration practices due to nomadism, Practice cattle rustling displaces population, Regional low economic status (poverty), Religious believe of prayers for healing

During treatment 76% of defaulters never experienced unstable living condition so it's not directly influencing defaulting. Also 61% of defaulters never associated their defaulting with immediate benefit of the therapy. It seems there is social stigma associated with defaulting because 43% of defaulters believe so, while 56% of defaulters have some religious believe against western medication.

4.6: Summary of factors associated with TB non adherence

The study found several factors that were associated with patient non-adherence to TB treatment within Baringo County. The study farther categorized the these factors into; patient related, health provider-patient relationships, pattern of health care delivery and socio-cultural factors influencing the non-adherence to TB treatment.

1. *Patient related factors*

The study indicates the following findings:

a) Defaulting is across all the age groups of TB patients.

b) Patient's marital status is not associated to non-adherence.

c) Treatment non adherence common at both treatment phases (intensive and continuation)

d) Older people fear hospital due to association of likely death outcome

e) The following are factors associated to non-adherence of tuberculosis treatment

   i. educational levels and income levels of patients

   ii. Smoking and Drinking habits

   iii. Financial challenges to support means of transport to access health facility

   iv. Experiencing symptoms relieve during treatment.

   v. History of not complying with medication of other diseases.

   vi. Experiencing drug side effects.

   vii. Presence of other sickness during tuberculosis treatment

   viii. Distance to health facilities

   ix. Preference to use traditional herbs instead of convectional(western) medicine

   x. Alcoholism habits

   xi. Commitment to cattle(wealth) caring than attending clinic days

   xii. Length of treatment (seem to be too long)

   xiii. Feeling of relieve after starting the initial dose

   xiv. Association with HIV(fear that they may be tested for HIV at the clinic)

   xv. Stigma associated from friends and relatives, if they attend near health facilities

   xvi. Drug/Pill burden

   xvii. Taste of drugs

   xviii. Experiencing drug side effects

   xix. Believe that TB is inherited

2. *Health provider-patient relationships factors*

There are several patient-health worker relation factors that are associated to non-adherence. The study found the following:

    a. The patients' forgetfulness or carelessness even after seeking clarification a detailed clarification from health providers.

    b. Experience of stressful events during treatment.

    c. Unpreparedness to disclose to family members and guardians about disease

    d. Stigma at home and workplace

    e. Stigma at workplace

    f. Fear of likely denial of conjugal rights associated due to disease

    g. Inadequacy of drugs distribution

    h. Staff shortage at level 1(Tier 1) health facilities

3. *pattern of health care delivery factors*

There are several health care deliveries pattern factors that are associated to non-adherence. The study found the following:

a) Patients ' experience less support from Health worker

b) Staff shortage at level 1(Tier 1) health facilities

c) Poor linkage between health facilities in service provision to encourage referrals

d) Poor referral systems from community to health facilities

e) Poor patient flow in standalone systems

f) Lack of adequate room to observe and examine patients

g) Poor relationship between private(clinics) and public facilities

h) Inadequate nutritional support

4. *socio-cultural factors*

There are several socio-cultural factors that are associated to non-adherence. The study found the following:

a) initiation ceremonies for example circumcision exclusion

b) Believe that TB is witchcraft and inherited in some families

c) Believe in the effectiveness of injection over oral drugs of 6-8 months

d) Migration practices due to nomadism

e) Practice cattle rustling displaces population

f) Regional low economic status(poverty)

g) Religious believe of prayers for healing

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1: Introduction

This chapter presents the study conclusions and Recommendations to the Baringo county Health Team.

5.2: Conclusion

Adherence to tuberculosis treatment is being faced with challenges that lead to non-adherence. The Non adherence is an issue of concern, its expensive in terms of losing life's, huge budget expenses, and deter economic and socio progress of the community. The factors that are associated to non-adherence range from: patient related, health provider-patient relationships, pattern of health care delivery and socio-cultural factors. The national health delivery system, County health team and community opinion leaders should address the recommendations below.

5.3: Recommendations

The following recommendations are made to the county health team to coordinate its implementation to achieve STOP TB aim.

1) Encourage health education that cuts across all ages, marital status, schools and settlements (residents). The health education messages that address the smoking and drinking habits during treatment periods, reliefs after initiation to treatment, drug side effects, stigma, preference of herbal over conventional treatment.

2) Consider either developing health facilities at crosser range, conducting mobile clinics, or use community health workers to deliver drugs at door step.

3) conduct update sessions to health workers and volunteers on medical counselling skills

4) maintain supply of drugs proportionate to prevalence

5) Seek partner support to support the inclusion of Community Health strategy in Community Health Volunteers   involvement.

6) Seek funding to build TB clinics at health facilities.

Table 1: Association of occupation to non-adherence

| | | | Do you associate your occupation with non-adherence? | | Total |
			YES	NO	
	Business person	%	33.3%	66.7%	100.0%
	farmer	%	31.2%	68.8%	100.0%
	casual	%	85.7%	14.3%	100.0%
	employed	%	25.0%	75.0%	100.0%
	Primary pupil	%	0.0%	100.0%	100.0%
	Secondary student	%	100.0%	0.0%	100.0%
	Tertiary student	%	100.0%	0.0%	100.0%
	Housewife	%	40.0%	60.0%	100.0%
Total		%	41.3%	58.7%	100.0%

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6.0: REFERENCES

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Coated Tool Inserts with Crater-Like Surface Topography Last Longer

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Abstract. *This paper presents the result of an investigation into the performance of Tungsten Carbide tool Grade –K inserts coated with titanium nitride (TiN). The TiN coating was done by physical vapour deposition process. Comparative cutting tests using control specimens coated with TiN having plain surface structures and tests specimens /inserts with crater-like surface topography. The surface roughness was created by electrical discharge machining (EDM) which generated an undulating surface roughness of 1.5 microns on the tools' rake face. This level of surface roughness was determined at earlier experiments. In both cases, the inserts were coated with TiN to a thickness of 4μm. The machining tests were carried out on Mild Steel grade EN-3 (AISI -1045_200Bhn). Various cutting speeds, up to an increase of 40% of the conventional tool manufacturer's recommended speed of 250 m/min were investigated. Thirty cuts (passes) were carried out for each inserts at the speeds investigated. After every five passes, microscopic pictures of the tool wear profiles were taken in order to monitor the progressive wear on the rake face and, on the flank of the insert. The power load was monitored for each cut using an on board meter on the CNC Lathe machine. Results obtained confirmed advantages of cutting at all speeds investigated using coated inserts with crater-like surface topographies in terms of reduced tool wear. It is therefore concluded, that TiN coated EDMed inserts with crater-like surface structure if coated with TiN performs considerably better than the plain inserts and lasts longer.*

Keywords: Coating, Titanium Nitride, Tool Life, Wear, Cutting, Tribology.

1.0 Introduction

There are many reasons for coating metal cutting Tools with hard substances such as Titanium Nitride (TiN), Titanium Carbide (TiC) and Aluminum Oxide (Al_2O_3).One of the reasons is to improve the tribological properties of cutting tools. Substantial amount of research has been doneon tool coatingswhich shows that tool coating by physical vapour deposition (PVD) processes exhibit an increase in the service lifetime of tools by a factor of ten compared to uncoated tools [1, 2, 3] and, according to Dobrzanski (2004) 'Coating tools with TiN is known to reduce friction in tribological contacts and increases the abrasive wear resistance' [4]. In addition to the enhanced wear resistance, 'TiN coatings can also provide oxidation resistance, especially at high temperatures' [5]-[10]. Demand for high quality machined surfaces has significantlyaffected the cost of production and in some cases; the price of a product. Metal machinists have been preoccupied with the search to obtain good work surface quality while endeavoring to maintain low production costs. In this study, comparative cutting tests were carried out using Cemented Carbide tool inserts. The tools underwent surface

modifications by electrical discharge machining (EDM) to a surface roughness of 1.5 microns. This window of roughness was identified in earlier experiments. After the EDM machining, the tools were coated with Titanium Nitride (TiN) to a thickness of approximately 4 μm by physical vapor deposition (PVD) technique in accordance with ISO 8504-2:2000 standards dealing with surface preparation methods –Part 2: Proper surface preparation was essential for the success of the coating scheme, as the performance of the coating was directly dependent upon the correct and thorough preparation of the surface prior to coating.

The coated tools were used for turning operations on Hitachi Seiki Computer Numerical Control (CNC) Lathe machine with a constant surface speed programmed. Different cutting speeds were used while maintaining the same depth of cut of 1 mm, and feed rate of 0.28 mm/rev throughout the experiments. The work material was EN3 mild steel in the form of 75 mm diameter, 300 mm long round bar billets. Various cutting speeds, up to an increase of 40% (350 m/min) of the tool manufacturer's recommended speed of 250 m/min for the conventional tool were investigated.

TABLE 1. Physical Properties of Workpiece, Tool and Coating Layer

Properties	Workpiece EN 3	Carbide Tool Insert	TiN Coating Material
Young's Modulus (GPa)	208	800x	500
Poisson's Ratio		0.2	0.25 Static
Yield Stress (GPa)	300		
Ultimate Stress (MPa)	386 – 540		
Specific Heat Capacity (J/m^{3}K)		203	2.50 x 10^6
Thermal Conductivity (W/m K)		46	90
Elongation (%)	25		
Vickers Hardness (HV)	145		
Density (gcm^3)	7.86	15	5.4
Linear Expansion Coefficient (^{0}C)	12.4 x 10^{-6}		
Coefficient of Thermal expansion (μm/m ^{0}C)		4.7 (at 20 ^{0}C) 4.9 (at 1000 ^{0}C)	
Rake face (degree)		-5	
Clearance Angle (degrees)		-5	
Melting Point (^{0}C)			2930 ±50
Molar Mass (g/mol)			61.874

2.0   EXPERIMENTALPROCEDURE

Two sets of experiments investigated tool based wear criteria (flank and rakewear) and a work based wear criterion (Workpiece surface finish) simultaneously. Control specimensi.e. plain TiN coated inserts and test specimens (EDMed inserts) all with chip breakers were used. Cutting speeds investigated were as follows:-

  i.   250 m/min which was the recommended cutting speed for the particular type of inserts to machine mild steel grade EN 3.
  ii.   300 m/min an increase of 20% of the tool manufacturer's recommended cutting speed
  iii.   325 m/min an increase of 30%.

3.0   Observations
3.1   Crater and Flank Wear
Crater wear is one of the factors that determine the life of a metal cutting tool. It is known that after some duration of cutting, cratering becomes so severe that the tool edge is weakened and eventually fractures or gets deformed. In this work, crater wear developed on the rake face of the tool. Wear on the flank was caused by friction between the newly machined work surface and the contact area on the tool flank.

3.2   Progressive Wear
The progressive wear of the tools took place in two different interesting ways as follows:
  (a)   Wear on the rake face developed as a crater resulting from the friction between the chip undersides rubbing along the tool rake face. Crater wear usually results from temperature activated diffusion or chemical wear mechanisms. Although the chips sliding over it has lower yield stress, it might have got so much work hardened as to be able to exert frictional stress sufficient enough to cause yielding by shearing off the hard tool metal on the rake face. It is known that the higher the temperature at the tool-work interface, the greater is the wear rate / effect.
  (b)   Secondly, wear on the relief face (flank) also developed at a point where a wear-land is formed by the rubbing action of the newly generated work surfaces against the tool cutting point. The wear-land developed and grew in size due to abrasion, adhesion, diffusion and shearing effect.

4.0   Discussion of Results
Analysis of the tools' rake and flank wear profiles indicates that there is less wear on the rake faces of the EDMed inserts compared to the control specimens. Results also show that, TiN coating on the rake faces of the control specimens appeared to wear off after only a short duration of cutting, whereas the coating on the EDMed surfaces noticeably held for a much longer duration of cutting. This result confirms what Wallén and Hogmark, (1989) stated that 'although, the coating is worn off by way of a crater, the remaining coating (along the rim of the wear scar) continues to offer resistance to wear' [11]. To explain this fact Kassman*et al* (1989) tried to prove the presence of a 'smear mechanism'. They assumed that TiN material was continuously transferred from the coated region at the edge on to the uncoated, thereby modifying the contact conditions by atomistic wear process [12] and hence reducing the wear rate.

The power load was monitored for each cut taken using an on-board meter on the CNC lathe machine to establish the amount of power needed for each stage of operation. The spindle drive for the lathe machine is an 11 KW/hr motor and themodified inserts operated at up to 18% reduced power consumption. Results obtained confirmed the advantages of cutting at all speeds investigated using coated inserts with crater-like surface structures, in terms of reduced tool wear and low power loads. Moreover, the surface finish on the workpiece was consistently better for the modified inserts.

Comparing the results, the surface finish deteriorates as cutting progresses for the control specimens. On the other hand the surface finish machined by the test specimens got better as the cutting progresses by the time the tools began to show signs of wear. This could be supported by the statement made by Stephenson and Agapiou (2006) that 'moderate crater wear usually does not limit tool life; in fact crater formation increases the effective rake angle of the tool and thus reduce cutting forces'[7]. On the other hand this could be an indication that the insert cutting tip has become round like that of a wiper insert normally used for finishing

cuts in a turning operation. The best surface finish values nevertheless, were obtained from the coated EDMed inserts.

5-0   Hypothesis
It can therefore be hypothesised that:
 i.   Coating metal cutting tools having undulating surface topographies to a thickness greater than the substrates surface roughness with hard materials like TiN or TiC permits higher cutting speeds and feeds, which may result in superior quality machining.
 ii.   The crater-like surface topography holds the coating in the valleys longer, thereby enhancing both the tool's performance and its operational life.

6.0   Conclusions
The results show that the inserts with crater-like surface topographies were capable of machining at a much higher speed than the plain inserts. The improved wear features of the modified inserts were sustained at higher cutting speeds in terms of a work based wear criterion than in the case of plain coated inserts. This study has proven that coatedinsertshaving crater-like surface topography have enhanced wear resistance which is more superior to the plain coated tool inserts [13]. This is significant because it indicates the possibility of higher tool life by way of tool wear compensation. Furthermore, the modified inserts operated at up to 18% reduced power consumption which means that coating of tools increases resistance to metal fatigue. The study contributes the following to current knowledge in metal machining:
 i.   Provide knowledge for increased tool life through wear resistance, hardness and chemical stability at high temperatures because of reduced friction at the tool-chip and work-tool interfaces due to tool coating, which leads to reduced heat generation at the cutting zones.
 ii.   Establishes that Undulating surface topographies on cutting tips tend to hold coating materials longer in the valleys, thus giving enhanced protection to the tool and the tool can cut faster by 40% and last 60% longer than conventional tools on the markets today
 iii. Provide technique for designing tool with roughened surface comprising of peaks and valleys covered in conformal coating with a material such as TiN, TiCetc which is wear-resisting structure with surface roughness profile compose of valleys which entrap residual coating material during wear thereby enabling the entrapped coating material to give improved wear resistance.

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Finite Element Analysis of Orthogonal Metal Machining

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Abstract

This paper presents simulation result of a study on the process of orthogonal metal machiningwith the finite element method using AdvantEdge^{TM} software. The software is a validated CAE software solution for the optimization of metal cutting, enabling users to analyze machining processes in 2D and 3D environments.The cutting process and mainly thecutting force is simulated from the initial state to the steady-state, by incrementally advancing the cutting tool, while a geometrical chip-separation criterion, based on a critical distance at the tool tip criterion was implemented by simulating in the AdvantEdge^{TM} engine. A series of finite element simulations were performed in which friction was modelledand executed along the tool-chip interface.A finite element nodal procedure was adopted in simulating chip separation from the workpiece. The results of these simulations were consistent with experimental observations. Specifically, it was found out that tool tip undergoes the largest plastic strain rate. Meanwhile, the maximum temperature rise which was a product of energy dissipation due to plasticity and friction occurred along the chip-tool interface.

Keywords: Finite Element, Chip Formation, Critical Distance, Nodes, Simulation, Metal Machining.

Nomenclature

C	constant
D	distance between the tool tip and the node candidate for separation
D_c	critical distance for chip or element separation
F_n	normal force
F_t	friction force
q	distributed heat flux due to convection heat transfer
q_f	distributed heat flux due to friction
Q	rate of specific volumetric heat flux due to plastic work
t	tangent unit vector in the direction of the relative velocity, v_r
T	temperature
V_r	relative sliding velocity between the chip and the tool rake face
W_h	percentage of plastic work converted into heat
W_p	rate of plastic work

ρ density

μ Coefficient of friction

1.0   Introduction

Finite Element Method analysis employs a number of finite points called nodal points covering the domain of a function to be evaluated. The subdomains within these nodal points are called finite elements [1]. Thus, the entire domain is a collection of elements connected at their boundaries without gaps. Each element connected to another by its nodes. The use of single point cutting tool in metal machining has been employed for generations in the production of components of various shapes, sizes and design specifications. Metal machinists have over time endeavoured to understand the mechanics of plane-strain orthogonal cutting to develop understanding of all machining procedures. The best analytical methods of orthogonal metal machining were first developed and presented by Merchant [2], who introduced the concept of the shear angle. This was followed by Lee and Shaffer [3], who proposed an analytical model using slip-line theory. Both models endeavoured to explain what takes place at the chip-tool interface. More accurate and sophisticated models have been developed lately with the advent of computer by incorporating the features of friction [4], work-hardening, strain-rate [5, 6] and temperature distributions [7]. In this study the finite element model used for the plane-strain orthogonal metal cutting simulation is based on the updated Lagrangian formulation in AdvantEdge^{TM}5.911 simulation software. The plane-strain supposition isthat in real metal cutting processes the width of cut is at least five times greater than the depth of cut and this is presumed to establish a reasonable approximation, since the chip is produced under nearly plane-strain conditions.

2.0   Chip Formation and its Separation

The criterion for the chip separation of nodes in front of the tool cutting tip is based on a geometrical consideration. It is presumed that cutting occurs along the line representing the undeformed chip thickness as illustrated in figure 2.1 below. Factually, separation is assumed to occur only at the nodes lying along this line. When the tool tip approaches a node, that node separates from the workpiece and forms into a chip.

Figure 2.1: Schematic illustration of the geometrical separation

In this study, machining process produced continuous chip and it was observed that the chip formation took place with microcracks extension in front of the tool tip. The chip separation phenomenon is a continuous process just ahead of the tool edge and this can be assumed geometrically based on critical distance as a

product of effective plastic strain and strain energy density [8]. In this study the critical distance was 4 μm and is considered small enough to produce continuous chips without distorting chips thickness. Shih and Yang,(1993)discussed estimation value for the critical distance and its effect on the accuracy and difficulties involves in obtaining a proper critical distance value. They argued that the results can only be validated experimentally in theirexperimental study on finite element predictions of residual stresses due to orthogonal metal cutting [9]. Meanwhile, Shaw [1] argues that determination of a steady state chip shape is easily done by finding the actual shape by iteration until the assumed and calculated flow fields correspond.

3.0   Heat Transfer

Temperature distribution in the workpiece, chip and tool affect the quality of the tool surface integrity. The high temperatures observed in the study are the product of both plastic work and the friction at the chip-tool interface, which are converted into heat.The rate of specific volumetric flux (Q) due to plastic work is given by the equation1 below used by Mamalis*et al* [10] in their study on FE simulation of chip formation in orthogonal metal cutting.

$$Q = \frac{MW_b W_p}{\rho} \qquad\qquad Equation\ 1.1$$

Where, the notation$W_p$is the rate of the plastic work, ρ the density, M the mechanical equivalent of heat to account for a consistent system of units and W_h the percentage of plastic deformation converted into heat which is about 90%.

The distributed heat flux generated at the interface between the chip and the tool rake face due to friction is described by equation2 below.

$$qf = F_t V_r \qquad\qquad Equation\ 1.2$$

WhereF_t is the contact friction force and v_r the relative sliding velocity between the chip and the tool rake face. This flux is split into two equal parts, assigned to each of the contacting parts which is at the chip and tool interface.

4.0   Modelling Tool and Work Materials

For this study AdvantEdge[TM]V.5.9011 machining simulations package was used because it integrates FE numerics and material modelling appropriate for metal machining. In addition it predicts and simulates material behavior during machining at a finite element level.

The simulation mode used was the recommended mode by the software supplier. This was the standard mode. Standard mode is better than rapid mode because it utilises a more refined mesh to provide extra reliable and accurate results.

Simulation Mode=   Standard (Long Swarfs without Burs)
- Steady State Analysis = 1 (allows user to compute steady state Forces and Stresses over a given length of cut). The length of cut must be 15x the feeds.
- Cutting Edge Radius = 0.6 set as default.

- Fraction of Feed = 0.1
- Mesh Refine = 2
- Mesh Coarse = 6
- Output Frame = 30
- Number of Threads = 1

The Coolant Information:
- Coolant = On
- Coolant Temperature = 20 ^{0}C
- Nozzle Location X axis = 4.0 mm
- Nozzle location Y axis = 3.0 mm
- Jet Radius (R) = 20 mm
- Jet Angle (A) = -50^0
- Coolant Jet Velocity = 50 m/sec

Tool Material:= Tungsten Carbide- Grade K
- Minimum Tool Element Size: = 0.02 mm
- Maximum Tool Element Size: = 0.1 mm
- Mesh Grading: = 0.4
- Number of Coating Layer: = 1
- Coating Materials: = TiN
- Coating Thickness 1: = 0.004 mm (4 μm)
- Aggregate Layer: = On

The simulation results were viewed in Tecplot window within AdvantEdge^{TM} by probing for data. By using the probing tool in AdvantEdge^{TM} simulation software, it was easy to see information about the specific point of interest for example cutting force.

Tool coating within AdvantEdge^{TM} FEM was done using thin layer of an explicitly-meshed coating of 3 μm. The thin coating was applied to the carbide tungsten tool in an effort to reduce small elements that may cause instability during simulation or cause the simulation to take significantly longer to run to completion.

The turning process parameters are given in table 1.1 below:

Table 1.1 Turning Process Parameters

Process Parameters
Feed (*f*):   0.28 mm/rev
Depth (*d*) of Cut: 1.0 mm
Length of Cut (*loc*): 10.0 mm
Cutting Speed (*V*):   325 m/min
Initial Temperature: 20 0C
Material: Mild Steel EN-3
Tool:Tungsten Carbide Grade –K coated with TiN
Tool Rake Face:
Tool Nose Radius:
Friction Coefficient: 0.6
Heat Transfer Coefficients = 10000 W/m²K

Mild Steel grade EN-3 (AISI -1045_200Bhn) was used throughout the study and it was modelled as isotropic elastic-plastic with strain hardening properties. It was observed that during the machining process the material deformed to form swarfs at 1100 ^{0}C and it experienced high strains and strains-rates. Details of the material deformations are in figure 6.2 to 6.4.

The Tool Wear Model used was Usui's Wear Model [14] because.

      a) It is possible to calculate Wear based on cutting velocity (speed) when using the Usui's Wear Model,

      b) In addition, nodal velocities are taken into consideration when calculating the tool wear rate, and the constant K has units of (1/**Pa**)

$$\dot{w} = K.e\left(\frac{Alpha}{T + 273.15}\right).\rho.v$$

Usui's Equation

Where **K** $(1/Pa) = 2^{E-9}$ and Alpha = 3000 are material constants, $\dot{w}$ represents the wear model (volume loss per unit area per unit time), **T** represents the steady state temperature of the tool with a given amount of wear, **V** is the sliding velocity, and **p** is the pressure

5.0   Friction Force Modelling

It is known that friction force is strongly influenced by tool shape, cutting speed, contact pressure and cutting temperature. Zorev's (1963) model reveals two distinct regions on the chip–tool interface; these are a sliding region and a sticking region [12].This implies that friction modelling in metal machining must account for both stick-slide situations. Modelling friction force as a distributed tangential force F_t, along the chip/tool interface, we used this formula derived by Iwata et al [13]

$$F_t = -\mu F_0 \frac{2}{\pi} \arctan\left(\frac{V_r}{C}\right)t$$

where, following the notation, μ is the Coulomb friction coefficient, F_n the normal reaction force, V_r the relative sliding velocity between the chip and the tool and $t = V_r/|V_r|$ the tangent unit vector in the direction

of the relative velocity. *C* is a constant representing the relative sliding velocity below which friction force starts dropping considerably to zero: in that way, sticking of the tool rake face is reproduced.However, friction has a lot of impact on metal cutting because it determines the power requirement for removing a given volume of metal and it also controls the surface quality of the finished product and the rate of wear of the cutting tool. Thus, from the discussion presented above it is accepted that two distinct contact regions, namely, the sticking and the sliding regions exist simultaneously along the tool-chip interface.

6.0   Results

When the simulation model was submitted for processing, the cutting tool initially indented the workpiece. When the cutting tool engaged the workpiece it advanced incrementally into the workpiece from the initial position by shearing the work into chips and the chip begins to form gradually until steady state is attained, i.e. the cutting force reaches a constant value.

Figure 6.1 The Cutting Tool engaged the Workpiece and sheared it into chips

The presence of the deformed chip, the cutting forces, and strain-rate distributions in the chip were observed through Tecplot window in the AdvantEdge^{TM}. In additionit was visible that the work-chip-tool interface zones experienced high temperature distribution.

The distribution of stress, strain, strain-rate and temperature in the deformation zone, could easily be visible though could not be measured experimentally but approximated by the finite element model, these results being in good agreement with reported results of other finite element orthogonal cutting models [13, 14, 15, 16, 18, 19]. Generally, the experimental results were in close agreement with Lin and Lin (1992) study on a

Figure 6.4: Illustration of plastic deformation transferring into heat

7.0   Conclusion

Baseon the discussion presented in this study, it is concluded that critical distance at the tool tip usually plays an important role in steady state metal cutting and chip formation due to the large strains involved. The model clearly demonstrated the chip separation criterion based on a critical distance consideration which has been achieved through the use of finite element code in AdvantEdge^{TM}. The model is able to predict the stress, strain, strain-rate and temperature distributions in the chip-tool-workinterface. A good agreement was found between the model and the experimental results, indicating the validity of the model in illustrating strain rate in metal cutting, heat distributionand chip separation criterion. The major findings of the study are:

a) The separation criterion in this finite element modelling of metal machining reflected the physics of separation at the tool cutting tip.

b) The maximum temperature and plastic strain occur away from the tool tip along the tool-chip contact interface.

c) The finite element model was simulated from the initial state to steady state. The simulation accounted for chip separation due to plastic strain criterion.

d) An adiabatic condition was assumed to allow plastic deformation to transfer into heat and its effect was evident in the deformed mesh.

e) The plastic strain and temperature distribution of the workpiece shows that the deformation concentrated at the primary and secondary shear zones. Though maximum temperature appeared on the tool rake face as a result of frictional heat of the chip rubbing along the face.

f) Good agreement of ± 10% was obtained at cutting speed of 325 m/min between the experimental and numerical simulation results in terms of tool life.

g) The chip formed into long spiral swarfs similar to those obtained in the cutting experiments showing agreements of ±5% see figure 7.1

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Assessment of Cloud Computing Adoption for E-Learning by Institutions of Higher Learning in Nairobi County, Kenya

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Abstract

The Cloud computing is a platform that facilitate a great advantage of flexibility and availability of cloud services and resources at cost-effective, high scalability and low energy usage through provision of applications as a service via the internet. This approach has uplifted the E-learning as a learning methodology involving digital with traditional learning support and delivery. Today, E-learning platform has been adopted by Kenyan private and public universities and institution with cloud computing as a new technique for managing content, teaching and learning aspect. This paper majorly assesses the cloud computing adoption, benefits and issues and integration concepts in an e-learning system in higher education.

1. Introduction and Background of the Study

Today global network has boosted the e-learning among many institutions with the integration of learning technologies with enormous IT infrastructure. The E-learning is a learning approach based on internet technology to initiate, implement, control and support learning which has enhanced flexibility and efficiency to traditional method of education (Viswanath, Kusuma, & Gupta, 2012).According to Ouahabi, Eddaoui, Labriji, Benlahmar, & Guemmat (2015) E-learning currently has overwhelmingly been adopted and is becoming a likely alternative to the traditional method of attending and learning in classroom. It integrate learning tools, materials and training content and services to enable efficient and economical delivery of educational content in a configurable infrastructure.

Cloud computing is not an exception; it has become a suitable platform architecture for E-learning system and education services (Sharma, 2014). The adoption of cloud computing for E-learning will pose numerous benefits which counter some constraints of e-learning systems in higher institutions. Joseph, Kathrine, & Vijayan, (2014) stated that cloud computing is a pattern of facilitating on demand network for access of the shared pool of resources virtually. However, virtualization technology has transforms cloud computing in a way to look like a physical resource to enable flexibility, availability and efficiently use of this logical resources such as storage, application and services. The cloud computing basically enable the access of the shared common resources, services and infrastructure available on demand to perform varied operations and task within the network that cope with the dynamics of business needs and environment (Kulkarni, Gambhir, & Palwe, 2012).Hence the place or location where the accessed resources are not aware by the users and not worried of management or maintenance of the virtual resources hence allow users to create, disseminate and control applications in the cloud.

The cloud computing service and application providers are giving higher education chance to alternate the presence method and enable institutions current data center, applications and replacing traditional and physical being in campus (Ouahabi, Eddaoui, Labriji, Benlahmar, & Guemmat, 2015). However, Maskare& Sulke, (2014) argued that traditional education is not able to cope with social aspects and changes within the society and the high demand of education and thereby a paradigm shift in the use of computer network and other technologies has bring an opportunity to catch up in educational development by used of this learning modes as virtual learning, virtual learning, web-based learning, network and distributed learning.

The competitive advantages aspect has compelled the higher institution to adopt and the implement the e-learning as an acceptable and formal mode of education delivery system. This decision has enabled the institution to benefits much. The pursuit for effectiveness, flexibility and low cost deployment of ICT infrastructure and strategies as prompted the institution to engage on a new paradigm of services and resources deployment and thus cloud computing is the way(Odunaike, Olugbara, & Ojo, 2012).

This study embarked on the aspects as benefits of cloud computing adoption on E-learning environments; and the issues of cloud computing adoption on E-learning environments. Generally the study carried out an assessment of cloud computing adoption for E-Learning environments in institutions of higher learning in Nairobi County, Kenya; especially in view to:-

i.   Establish the extent of cloud computing adoption for E-Learning environments in institutions of higher learning in Nairobi County, Kenya.

ii. Assess the benefit of cloud computing adoption for E-learning environments in institutions of higher learning in Nairobi County, Kenya.

iii. Examine the issues of cloud computing adoption for E-learning environments in institutions of higher learning in Nairobi County, Kenya.

2.   Cloud computing

NIST (2011) define the cloud computing as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction". Consequently, Bhure & Bansod (2014) terms it as both applications and services residing within a network that is distributed and resources accessed virtually through internet protocols as well as appropriate networking standards which reveals the physical systems as an abstract to the user through abstraction and virtualization technology concepts.

According to Mokhtar, Ali, Al-Sharafi, & Aborujilah (2013) argued that despite increased adoption of cloud computing especially in the industry and service sectors which involved 96% while only 4 % within the education sector. Also, the swelling use of cloud computing as resulted in tremendous growth of $40 billion in 2011 to approximately $240 billion by 2020 in the market. According to Odunaike, Olugbara, & Ojo (2012) argued that the market share and growth has overwhelmingly increased   due to cloud computing Moreover, from his studies the cloud computing global market growth shifted from $40.7 billion in 2011 to almost $241 billion in 2020. The public cloud total size is predicted to shoot from $25.5 billion in 2011 to $159.3 billion in 2020. Added that Forbes indicated $12.1 billion cloud computing growth of service in 2011 which is approximated growth value of $35.6 billion by 2015.Additionally, Saraswathi & Bhuvaneswari (2013) stated that cloud computing enables availability of services 24/7 anytime-anywhere to the user without accountability of maintenance of applications or rather the location of such services since they are in charge service providers (i.e. Amazon EC2, Google). Gokuldev & Leelavathi (2013) pointed out that Cloud computing "are a new computing paradigm that is built on virtualization, parallel and distributed computing, service-oriented architecture, and utility computing". Consequently most of the cloud computing concepts and cloud services commonly users do interact on daily basis include but not limited to Gmail Docs, drives and Google Calendars, Apple's iCloud, Microsoft's SkyDrive, Dropbox and Samsung's SCloud (Jeong, Kim, & Yoo,2013).

The higher education in the entire globe has embraced cloud computing for instance UK institutions (e.g. Leeds Metropolitan University, the University of Glamorgan, University of Aberdeen and etc.), US (University of California, Harvard University etc.) as well as Africa (Sultan, 2010). According to Drissi, Ouman, & Medromi (2013) there are a number of classification models of cloud based on their uses, such as cloud Platform as a Service (PaaS) that offers environment implementation virtually of services for instance Google App engine etc., Moreover it facilitate users to deploy and perform specific task on application software's in the cloud with the tools, languages, functions, libraries and services enable by the service provider (Odunaike, Olugbara, & Ojo, 2012). cloud Software as a Service (SaaS) that offers software applications through the internet as a service like Google Docs, Salesforce.com CRM, Zoho Office etc. and cloud Infrastructure as a Service (IaaS) that facilitate computing of resources virtually i.e. Amazon EC2. Bhure & Bansod (2014) too acknowledge that IaaS offers virtual machines, infrastructure and storage which availed resources to the clients and interactivity with the system applications.
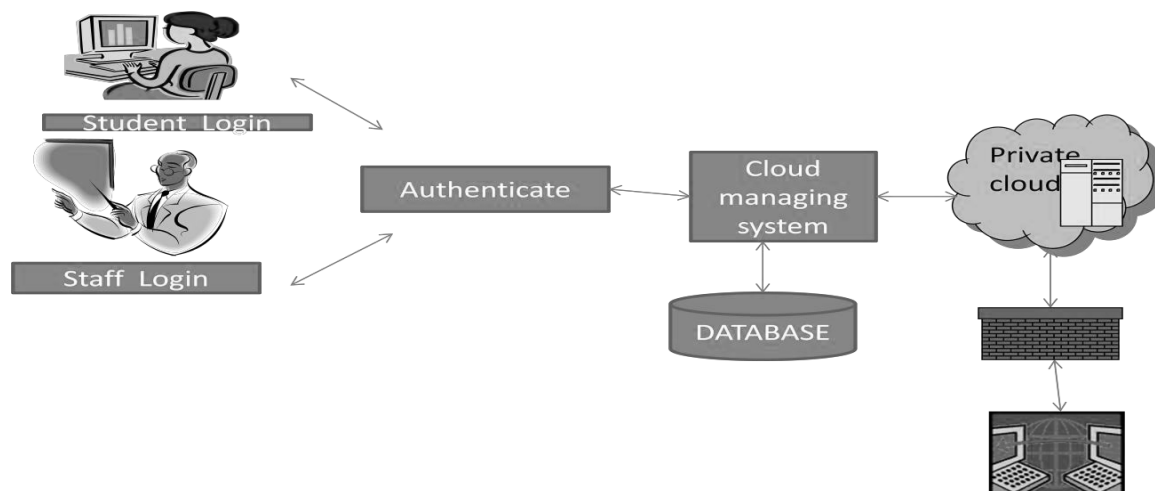
2.2 E-Learning

Sangra, Vlachopoulos, & Cabrera (2012) define the E-Learning as the use of the electronic media for a multiplicity of learning reasons that vary from add-on functionalities in a typical classrooms to full replacement of the face-to face encounters through online sessions or a distance education system by use of remote resources. According to Kakoty, Lal, & Sarma,(2011) the E-learning revolution as enable new education dimensions which has turn the world as a global village and get rid of barriers of time, place, time, age, social and economic aspect. The E-learning provides a platform incorporating ICT resources enabling students and teachers interactivity with online environment. The E-learning have revolutionized the distance learning by utilizing a combination of mass- latest technologies in structuring practices involving teaching, learning and education (Sangra, Vlachopoulos, & Cabrera, 2012).

Jeong, Kim, & Yoo (2013) affrimed that a number of institutions have now embraced the E-Learning by incorporating the cloud computing technologies within the academia therefore offering a more flexible, scalable, efficient and reliable learning content. Additionally, they stated that universities nowadays are now utilizing opportunities of cloud computing for distance learning as well as economic benefits and privileges. The various institutions utilized E-learning to spearheads learning solutions through a number of educational levels ranging from academics training, company trainings and so on involving entities as the students [online course , exams , homework, projects] and the trainers[notes , Cats, assignment dissemination] (Bhure & Bansod ,2014).

Adhyapak (2015) stated that the demand for education development within the society is growing all the time and therefore quality, improved and advanced e-learning solutions is obligatory which is demanded and must go in hand with technology dynamics and consequently, the adoption and use of cloud computing is essential. Also the institutions around the world are increasing burden to devote and use the ICT to manage and served all the wellbeing of the students, staff and management fraternity which are overwhelmingly doubling every intake.

Fig 2.3   Private cloud Architecture in E-Learning

Source: Adapted from Adhyapak (2015)

The implementation of E-learning within the higher institutions is faced by various challenges and the universities that want to adopt and implement the idea must be ready to tackle the challenges that can be encountered in the process such as infrastructural challenge, legal issues, security issues, social and cultural challenges, leadership challenges among others. Most universities in Kenyan is forced to align with the vision 2030 hence needs to blend the education system with the e learning as alternates for traditional system delivery of knowledge (Tarus, Gichoya, & Muumbo, 2015). They also indicated that according to the survey on Kenyan universities a number of them have adopted the e learning where at some point they combined with the face to face learning such as seminars, Cats and Exams administering. Among this Wedusoft platform was the e learning initially first launched by University of Nairobi in the way back 2004, Kenyatta University started theirs in 2005 where they used Moodle while Moi University launch MUSOMI as e–learning platform in 2007.Consequently, today the Kenyan universities both public and private have taken a step in inclusive of collaboration technologies and other e learning paradigm as cloud computing to improve quality and efficiency of education sector.

2.3 Benefits of Cloud Computing

According to Patil & Babu (2013) among the benefit of cloud services is that they require no capital investment for the users to access with neither geographical nor time limitation, efficiency, flexibility, cost reduction, scalability and pay per use criteria.

Sultan (2010) indicated that the used of pay–as you-go model has enable the users to enjoy simplicity, accessibility and economics where no cost incurred in terms of architecture, application installation and labour. This is because installation and maintenance are not locally run on the IT infrastructure but is cloud – based and thus the company, organization or institution is free from cloud architecture-related expenses shifted to external providers.

El-Ala, Awad, & El-Bakry (2012) affirmed that cloud computing is able to saves cost required for advancement of various labs' software's and hardware licenses or purchase and can also lessens the user of regular maintenance as well as enabling a high degree of privacy and security. However, most of the Universities are acknowledging the capacity of cloud computing in the improvement effectiveness, efficiency, reduction in cost and convenience in the educational sector (Sultan, 2010).

According to Bhopale (2012)summarizes benefits of cloud computing as unlimited scalability, reduced cost, increased storage, automation, flexibility and better mobility; moreover, Sharma (2014) pointed out reduction in cost, infrastructure flexibility, virtualization, ease monitoring and access of data, unrequired data backup and the availability increased. Therefore the adoption and implementation within the Kenyan higher institution would greatly boost and improved education quality.

The adoption of cloud on e-learning has much improved performance as a result of running the processes and applications within the cloud and thus client machine cannot create problems based on performance problems (Viswanath, Kusuma, & Gupta, 2012).Jain & Chawla (2013) argued that cloud computing is cost effective since the university is liable to server space, updates and maintenance cost. In addition the data access control

and monitoring is simpler since a single place require supervision .The aspect of virtualization too help in minimizing cloud downtime.

2.4   Issues of Cloud Computing

Cloud computing as a new technology paradigm is fastened with uncertainties and fears on concerns relating to control, performance, vendor lock, security, privacy, latency and reliability (Sultan, 2010).

Security - The confidentiality and privacy of data within the cloud entrusted to the service providers is questionable and thereby many academic institutions are reluctant to embrace the idea of cloud computing. Thereby there concern of cloud computing to effectively handle regulations on privacy (Maskare & Sulke, 2014; Mokhtar *et al*, 2013).

Lack of control - The users lack the freedom to physically own and control their data stored in cloud since they are left in the hand of the third party or the cloud service providers (Viswanath, Kusuma, & Gupta, 2012).

Bandwidth - Since the cloud computing is an internet based service; it is quite challenging to offer education services effectively in such a case the bandwidth is limited especially the deployment model as public cloud (Mokhtar *et al*, 2013).

Educational management rules - The control, monitoring and management are quite difficult with cloud computing in relation to the traditional education that decision makers and management board are used to in control of teaching, content and examination within the institution, hence reluctant in implementation (Mokhtar*et al*,2013; Avram, 2014)

3.   Discussion and Conclusion

The various services offered through web services(such as Google Maps) , utility computing including infrastructure as a service(IaaS), software as a service(SaaS), and platform as a service (PaaS)where the end users exploit these services using browsers via   internet. The SaaS application involved sales force applications, CRM applications, ERP applications, meeting applications, Google Apps i.e. Google Talk, Gmail, Google Calendar, Google Docs (e.g. spreadsheets, collaboration), etc., and Microsoft Windows Live such as Messenger ,Hotmail, Photo Gallery (Kim, 2009)

Jeong, Kim, & Yoo (2013) argued that a number of institutions are embraced the E-Learning by incorporating the cloud computing technologies within the academia therefore offering a more flexible, scalable, efficient and reliable learning content. Consequently, Mircea & Andreescu, (2011) expounded various instances of utilization of cloud computing services in universities in the whole world and regionally, this include Virginia virtual computing lab as a composition of Commonwealth colleges and universities. Moreover, North Carolina State University have facilitated the cloud services through software licensing cutting cost and time saving among IT campus staff. Kuali Ready is also a chartered community-source project facilitating cloud computing services as higher education institutions.

According to Sultan, (2010) the benefits and opportunities of utilizing cloud computing among higher education institution as Washington State University's School of Electrical Engineering and Computer Science, University of California, institutions from UK, U.S, Africa and so on .The Cloud computing infrastructure and technologies have allowed most of the institutions to enjoy the services even without technical expertise host own platform. It has given the freedom for everyone to deploy their tools to enjoy on demand services and application as, Google Docs, YouTube, Spread sheets, etc. The institution globally have benefited from the service to enabling them to cut cost of implementation, maintenance, data storage, security ,computing power that allow both trainers and students enjoy proprietary tools and applications as virtual office, databases, spreadsheets, and social software (Al-Zoube, 2009). Bhopale (2012) stated key privileges of cloud computing among them are unlimited scalability, reduced cost, increased storage, automation, flexibility and better mobility; Additionally, Sharma (2014) outlined the reduction in cost, infrastructure flexibility, virtualization, ease monitoring and access of data, unrequired data backup and the availability increased. Therefore the adoption and implementation within the Kenyan higher institution would greatly boost and improved education quality.

The Cloud computing has enables the institutions to meet customer satisfaction and deliver quality service in low cost with efficiency and effectiveness. The journal articulated the cloud services, deployment model, adoption, benefits, issues of cloud computing and incorporation of e learning among the higher education institutions. The pressure of large intake of students, education content growth and dynamic change of IT has necessitate most universities to seek alternatives solution in their e-learning which has promote high spending ,lack of efficient resource utilization and scalability on the current systems of learning. Therefore, not only international institutions in UK and US but also in Africa especially Kenya such as University of Nairobi, Kenyatta University, Jomo Kenyatta University of Science and Technology, Strathmore etc. are now reaping benefits of cloud computing adoption and incorporation in their e-learning within higher education (Jain & Chawla, 2013).

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PERFORMANCE OF COATED TOOL HAVING UNDULATING SURFACE STRUCTURES

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Abstract

This paper presents results of a study on the effects of both tool surface profile and friction coefficient on cutting tool during chip formation processes. The computational procedure for modelling in the study involved simulating orthogonal metalmachining with a tungsten carbide toolhaving undulating surface topography and coated with titanium nitride. A series of finite element simulations were performed according to Largrangian-Eulerian formulations. An arbitrary Largrangian-Eulerian (ALE)formulation is used because it combines both advantages of Eulerian and Lagrangian representations in a single description and it helps to reduce finite element mesh distortions. The machining parameters were: 1 mm depth of cut, with a feed-rate of 0.4 mm/rev and cutting velocity of 325 m/min. Furthermore, it was ascertained that the maximum temperature reached, the contact length, the shear angle, and the cutting force were dependant on the coefficient of friction (μ). The coefficient of friction used in this study were; 0.3 and 0.4.It was observed that a thin film of coatingplays a great part in tool life and chip formation.

Keywords*: Simulation, modelling, orthogonal, metal machining, friction, coefficient, Von Misses*

Nomenclature:

C	=	*capacitance matrix*
T	=	*array of nodal temperatures*
V_c	=	*Chip velocity*
V	=	*Cutting speed*
μ	=	*Coefficient of Friction*
ϕ	=	*Shear angle*
q	=	*Constant of proportionality*
TiN	=	*Titanium Nitride*
FE	=	*Finite element*
FEA	=	*Finite Element Analysis*

T_p	=	Load bearing ratio
τ	=	shear flow stress
τ_f	=	frictional stress
σ	=	normal stress
t_1	=	Chip thickness before cut
t_2	=	Chip thickness after cut

1.0 Introduction

Thin film coatings are known to be useful in tool design and manufacture as conventional metal cutting tools are now widely coated to give better quality and durability when in use. Coatings are used to control friction and wear in all kinds of contact. This is reinforced by a large amount of evidencefreely available in published literatures about the behaviour of coated surfaces in tribological contact. Some of the prominent researchers are;Marusich and Ortiz [1] who developed unsteady-state models applied to metal cutting followed by Obikawaet al[2]who applied computational machining method to discontinuous chip formation. Prior to these, Shih and Yang [3] presented an experimental and finite element prediction ofresidual stresses due to orthogonal metal cutting. A thermo-mechanical model which predicts residual stresses in the workpiecewas presentedby Strenkowski and Carroll [4]. Lin and Pan [5],provided comparative experimental findings on tool forces.Sekhon and Chenot [6]showed tool forces and stresses distributionin numerical simulation of continuous chip formation during non-steady state orthogonal cutting.

1.1 Machining Experiments

Duringthe machining experiments/ study, the chip tended to spread askew, causing the maximum width to become wider than the original depth of cut. For consistency in this study the irregular cross-section of chips produced were measured with digitalMicrometre. The chip generated by tool having undulating surface topographycoated with TiNwere measured and found to be 1.43 mm, (t_2)and for the conventional tool, the chip thickness was 1.53 mm, notwithstanding; all cutting parameters remained the same in the study. While the depth of cut was maintained at 1 (mm) in both cases according to convention therefore t_1 is the chip thickness before cut. It could therefore be seen that the chip thickness ratio, t_2/t_1, is geometrically related to

the shear plane angle, Φ, by the following equation

$$\cot\emptyset = \frac{t_2}{t_1}$$
<div align="right">*Equation 1.0*</div>

The chip moved away with a velocity V_c, which is related to the cutting speed, V, and the chip thickness ratio, t_2/t_1, by equation:

$$V_C = V\frac{t_1}{t_2}$$
<div align="right">*Equation 1.1*</div>

2.0 Modelling Approach
2.0.1 Simulating the Model Systems

The computer simulations modelling were performed usingThird Wave Systems AdvantEdge[TM]V.5.9011 machining simulations software, which combined with advanced finite element numeric and material modelling appropriate for metal machining. The AdvantEdge[TM]software is an explicit dynamic, thermo-

mechanically finite element model specialised for metal cutting. The main features in AdvantEdge[TM]available to model metal cutting accurately included adaptive remeshing capabilities for resolution of multiple length scales such as innovative cutting edge radius; secondary shear zone and chip load; comprising of multiple deformable contacts for tool-work interaction, and transient thermal analysis. The workpiece moved with velocity (*V*).Rake and clearance angles of 5^0, plus cutting edge radius of 0.8mm parameterised the cutting tool. In the plain strain the depth of cut into the plane was large in comparison to the feed. A schematic illustration of the cutting conditions is demonstrated in Figure 1.0 below.

Figure 1.0. Schematic Presentation of the Cutting Conditions

When the model was submitted for processing into the AdvantEdge engine, the cutting tool was seen to initially indent the workpiece as shown in Figure 1.1 below, and the chip begun to form as seen in Figure 1.2.

Figure 1.1 the Cutting Tool initially indents the Workpiece

Figure 1.2 The Chip begun to Curl round and hit the work

As the tool travelled along the workpiece the chip curled round and hit the workpiece

The simulated cutting process produced a balanced linear momentum of forces involved in the cutting processaccording to Ozel, and Atlan, [7] earlier study. The balance of linear momentum is therefore written as:

$$\sigma_{ij,j} + \rho_{bi} = \rho_{\ddot{u}j}$$ Equation 1.2

The weak form of the principal of virtual work becomes:

$$\int_B V_i \sigma_{ij,j} + V_i \rho b_i \, dV = \int_B \rho V_i \ddot{u}_i \, dV$$ Equation 1.3

Integration by parts and rearranging terms provides:

$$\int_B \rho v_i \ddot{u}_i \, dV + \int_B v_{i,j} \sigma_{ij} \, dV = \int_{\partial B} Vi \sigma_{ij} n_j \, d\Omega + \int_B V_i \rho b_i dV$$ Equation 1.4

This can be interpreted as:

(Inertial Terms) + (Internal Forces) = (External Forces) + (Body Forces)

Consequently, finite element (FE) discretisation provides:

$$\int_B \rho N_a N_b \ddot{u}_{ib} dV + \int_B N_{a,j} \sigma_{ij} \, dV = \int_{\partial B} N_a \tau_i \, d\Omega + \int_B \rho N_a \, b_i dV$$ Equation 1.5

In matrix form:

$$M_a + R_{n+1}^{int} + = R_{n+1}^{ext}$$ Equation 1.6

Where:

$$M_{ab} = \int_{BO} \rho_0 \, N_a N_b dv_0$$ Equation 1.7

is the mass matrix

$$R_{ia}^{ext} = \int_{BO} b_i N_a \, dV_O + \int_{\partial B0\tau} \tau_i \, N_a d\Omega_O$$ Equation 1.8

Which is the external force array and:

$$R_{ia}^{int} = \int_{BO} P_{ij} N_{a,j} dV_O$$ Equation 1.9

is the internal force array.

In the above expressions, N_a, $a = 1, \ldots,$ are the chip shape functions, repeated indices imply summation, and a comma (,) represents partial differentiation with respect to the corresponding spatial coordinate, and P_{ij} is the first Piola-Kirchhoff stress tensor, analogous to the engineering or nominal stress.

3.0 Observations

It was observed that the stress distributions at the chip–tool interface exhibited sticking and sliding processes as inZorev's model[8], showinggreater force at the stiction region and lower force at the sliding region. See figure 1.3 below.
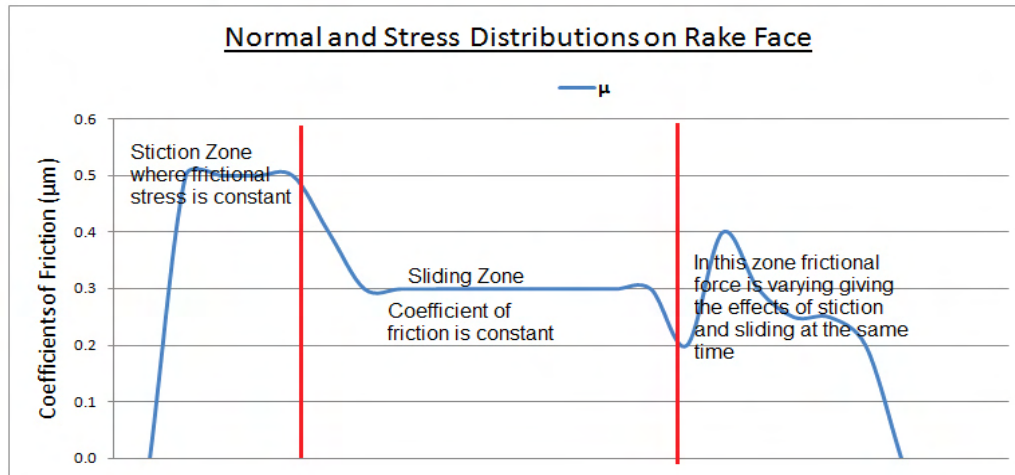

Figure 1.3:Normal and Frictional Stress Distributions on the Tool Rake Face

The study established that the stress distributions at the chip–tool interface are high and realised that the force is greater at the stiction region and low at the sliding region.

3.1 Heat Generation and Distribution

The heat rate distribution at 12500 W/mm was greatest at the tool cutting tip zones along the tool flank where the flank rubbed against the machined surface and at the rake face where the swarfs rubbed at the chip-tool interface. There was also high heat rate distribution at both the primary and secondary shearing zones as the chip began to deform into a curl.

Figure 1.4: Showing Initial Heat Rate Distribution

Meanwhile the heat conductivity matrix is in equation 1.13, and

$$Q_a = \int_{Bt} sN_a dV + \int_{B\tau q} hN_a dS \qquad \text{Equation 1.14}$$

The heat source array is illustrated by equation 1.14 above, with **h** having the appropriate value for the chip or tool.

Since tool wear is dependent, on 'cutting temperature, contact stresses and sliding velocity' produced during metal cutting, and hence by applying Amonton's laws of friction, the following assumptions were arrived at:

i.   During sliding, the resistive force per unit area of contact is constant which means $F = A.s$ where F is the friction force, A is the real area of contact and s is the frictional force per unit area.

ii. The real area of contact A, is proportional to the normal load W, which means that $A = q.W$ where, q is the constant of proportionality.

Thus, by eliminating A from these two equations gives $F = q.s.W$ which confirms that the friction force is proportional to the normal load when the contact is plastic (Ozel, and Atlan, [10], also discussed by Michael, and March [11], regardless of the surface topography, and also whenever the contacting surfaces have exponential asperity height (in this case undulating surface topography) distributions, and regardless of the mode of deformation as a result of linearly increasing load. Taking the linearly increasing load to be, $m_l = \dfrac{x}{l}$ m_A,

By integration, considering that $a = 0$ and $b = l$, the equation becomes:

$$F_w = \int_a^b mlg\, dx \qquad \text{Equation 1.15}$$

$$\text{Which becomes} \quad Fw = \int_0^l \frac{x}{l} mAg\, dx$$

$$= \frac{mAg}{l} \left(\frac{x^2}{2}\right) \frac{l}{0} = \frac{mAgl}{2} \qquad \text{Equation 1.16}$$

The result for F_w is equal to the area of the loading X_g. This value X_g is equal to the distance to the centroid of the area of loading which means that equation

$$F_w X_g = \int_a^b mlgx\, dx \qquad \text{or}$$

$$X_g = \frac{\int_a^b mlgx\, dx}{\int_a^b mlg\, dx}$$

$$\text{becomes} \quad X_g = \frac{\int_0^l (mAg/l)x^2\, dx}{mAg\, (l/2)} = \frac{2}{3} l \qquad \text{Equation 1.17}$$

Taking m_l = mass of the load per unit area and length (l) is constant.

Thus (force) $F_w = mlgdx$

$$F_{w=} \int_a^b mlgdx \qquad \text{Equation 1.18}$$

3.2   Chip Loading

The study looked at the chip loading to establish the stiction and frictional effect due to stress distributions. The chip loading appeared to be uniformly distributed over the tool rake face, the total weight was assumed to

be in the centre of the distributed load. The total force (F_w) was given by equation 1.18 above, where l was the length of the chip. While the total force F_w was assumed to act on a rigid body so that the moment of this force about any point was the same as the moment due to the distributed load, this point was presumed to be a distance X_g from the left-hand end of the chip A. Thus, the moment of the equivalent force F_w about A must be equal to the sum of the moments of the weights of the individual elements of the distributed load. Mathematically given as:

$$X_g = \frac{\int_a^b mlgxdx}{\int_a^b mlgdx} = \frac{l}{2}$$
Equation 1.19

The approach combines both Eulerian-Lagrangian models as explained above and the tool–workpiece contact algorithm and agreed with Lin and Lin, [12], Devillez et al[13] for sliding-sticking friction conditions based on this relation

$$\tau_f = \tau\left[1 - e^{-\mu\frac{\sigma}{\tau}}\right]$$
Equation 1.20

Where τ_f is the friction stress, σ is the normal stress and τ is the shear flow stress, and $\mu = 1$ based on experimental force measurements.

4.0 Output Data from Simulation
The following outputs were observed from the simulation.
Table 4.0 Outputs of the Simulation Modelling

Factors	Maximum Output	Units
ToolTemperature	1100	^{0}C
Conventional Tool Temperature	1300- 1500	^{0}C
Von Mises Stress	1000	MPa
Plastic Strain	1000	/sec
Heat Rate	12500	w/mm

The low temperature, plastic strain and von misses stress are due to the young's modulus between the TiN coating and the substrate because for the same value of strain, the stresses are proportional to the stiffness of the materials Shih et al[13]. In this study, Usui's Wear Model is used because of two reasons.
   a) It is possible to calculate Wear based on cutting velocity (speed) when using the Usui's Wear Model, and;
   b) In addition nodal velocities are taken into consideration when calculating the tool wear rate, and the constant K has units of (1/Pa), thus;

$$\text{Usui's Equation } \dot{w} = K.e\left(\frac{Alpha}{T + 373.15}\right).p.v$$
Equation 1.21

Where K ($1/Pa$) $= 2^{E-9}$ and Alpha $= 3000$ are material constants, $\dot{w}$ represents the wear model (volume loss per unit area per unit time), T represents the steady state temperature of the tool with a given amount of wear, V is the sliding velocity, and p is the pressure

5.0   Analysis of the Simulation Results

The workpiece material was Mild Steel EN-3 BS970 with the following properties;

Table 5.0: Physical Properties and Chemical Composition of Mild Steel EN-3

Properties	Parameters
Density (g cm^3)	7.85
Carbon Content	0.16% - 0.25%
Young's Modulus (GPa)	210
Sulfur	0.05%
Melting Point	1426 – 1538 ^{0}C
Phosphorus	0.05%
Manganese	0.5 – 0.9%

Meanwhile, the properties of Titanium Nitride are given in table 5.1 below

Table 5.1: Properties of Titanium

Properties	Parameters
Density (g cm^{-3})	5.2–5.44
Melting Temperature (^{0}C)	2948 ^{0}C ±50
Thermal Conductivity (W m^{-1} K^{-1})	24 (400 K) 67.8 (1773 K)
Young's Modulus (GPa)	251 – 616
Thermal expansion (K^{-1})	8 x 10^{-6}
Hardness (HV)	2,000 – 2,500

The study established that the cutting forces increased until it reached steady state, at which point the cutting force no longer increased. The power load and steady state cutting forces were compared with the laboratory experimental data obtained in earlier cutting tests and found to be comparable with a disparity of ±10%. Meanwhile, the swarfs produced during machining experiments and those seen at the simulation modelling were within ±5% agreement (see figures 1.7, 1.8 and 1.9) below.

Figure 1.7: showing long shiny Swarfs in a Tray in the machining centre compartment.

Figure 1.8: Thin Long Spiral Shiny Swarfs produced by TiN coated tool with undulating surface
Chip thickness (t$_2$) = 1.43 mm.

Figure 1.9: Thicker Dark Bluish Swarfs produced by conventional tool inserts
Chip thickness (t$_2$) = 1.53 mm

Results from the simulation modelling of the tool with undulating surface structure showed mean temperature readings of 1100^{0}C at the tool-chip interface which was comparatively low since results for conventional tool showed high temperatures of between 1200 ^{0}C – 1300 ^{0}C. The effect of the high temperatures is visibly evident by the swarfs colour in figure 1.9 above.

The low temperature effects allowed the tool to last longer due to reduced friction between tool flank and the newly machined surface Astakhov, [14]. The low temperature was due to the Titanium Nitride (TiN) coating which was held longer on theundulating surface structure of the tool topography. TiN has high lubricity and melting point of 2948 ^{0}C

One reason for this decrease in temperature and stress (see table 5.1 above) is that TiN coating has very high lubricity, which resists the formation of a built-up-edge, and this property helped decrease friction along the tool work interface,this phenomenon was reported by Guo, and Lin, [15]also cited in Bhatt, *et al*, [16]. Therefore, stress is accordingly lower.

It could be seen in the model that the chip formed into long spiral swarfs which were similar to those obtained in the cutting experiments as seen in figures 1.6 and 1.7above. Presumably, due to the adiabatic conditions assumed in the Finite Element Analysis (FEA) model.

Conclusion

Considering the linearly increasing load assumptiondiscussed in section 3.2 above for the coated tool insert withundulating surface topography,it can be presumed that the TiN coating propertiesand the adiabatic condition lead to a low temperature (1100^0C) being generated. This temperature is quite below Titanium melting point of 2948^0C, (1941K / 3034^0F).The TiN coating provided excellent lubricity and tribological properties, because of the coefficient of friction of 0.3 to 0.4thus giving very low wear rate.

This means that the chip was softening fast and less cutting force was needed to deform itresulting in long grey shiny swarfs as seen in figure 1.8. On the other hand, for the conventional tool insertswhose coatings got worn off faster due to high friction, cutting pressure/ force muchhigher temperatures of between 1300 ^{0}C – 1500 ^{0}C wererecorded. The temperatures are presumed to be due to high friction between the chip and tool rake face and adiabatic conditionsat the chip-tool interface, thus, generating thickerdark bluish swarfs as seen in figure 1.9.The following deductions are arrived at:

i. The model of the modified tool exhibited low temperature, which could be attributed to low friction at the tool-work interface due to coating effect oftitanium nitride, which remained on the EDMed tool surface longer and continued to lubricate the surface by atomisation. Thus, generating swarfs as seen in figure 1.8. This is in agreement with the findings of Atkins and Anthony, G, [17], on friction in cutting.

ii. The value of friction coefficient is dependent on the presence of TiN coatings on the tool surface, which continued to provide lubricity.Titanium has afatigue limitwhich guarantees longevity Stwertka, [18] especially in friction. Thus giving longer tool life and better performanceCostes, *et al*, [19]

i. It is presumed that the low temperature is due to the lubricity properties of the TiN coatings on the tool surface roughness (Ra) and its load-bearing ratio (T_p) capability. The value of friction coefficient is dependent on the presence of TiN coatings on the tool surface. The TiN provided adequate lubricity (low friction) with respect to the work material, thus; prevented BUE.

iii. The study agreed withZorev [8] model illustration of the sticking and sliding regions inmetal cutting process with a single point cutting tool.

As could be seen in the mesh the coated undulating inserts retained the coating longer in the valleys because of improved adhesion properties of the coatings onto the tool undulating surface, this helped to reduce friction or heat generation at the tool-chip interface giving better tool performance Ozel, T., and Atlan, [12] also in Zhou, *et al*, [20]and longer tool life.

It can therefore be hypothesised that:

i. Coating metal cutting tools with undulating surface topographies to a thickness greater than the substrates surface roughness with hard materials like TiN or TiC permits higher cutting speeds and feeds, which may result in superior quality machining.

ii. The crater-like surface topography holds the coating in the valleys longer, thereby enhancing both the tool's performance and its operational life.

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Women Managers and their Perceived Barriers for Upward Mobility in Public and Private Sectors with Special Reference to the Selected Services in Sri Lanka

by

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Abstract

The aim of this study is 'to explore the barriers that impede career development of Sri Lankan women managers in public and private sectors'. In this study, an interpretivist philosophy as the researchers view and the respondents view has adopted. Qualitative case study methodology with feminist-oriented research method was used to answer the questions. By this study, it has been analyzed the experiences of 40 Sri Lankan women who are holding senior-level management positions in five public and five private sector organizations. The grounded theory analysis method was applied to analyze the data. The findings confirmed that women remain under-represented in top management positions. Organizational culture, situational and personal factors have affected these situation. However, the study confirmed that the Organizational cultural, situational and personal factorsare not affecting managerial effectiveness of the women managers. Generally, they do not show dialectical behavior in their managerial positions and use their style in a non-traditional manner. There is still a need to push for equal representation of women in top management positions in both sectors.

Key Words:-Women, Managers, Public Sector, Private Sector, Organizational Culture, Situation, Personal, Effectiveness, Management Style.

1. Background of the Study

An important change in the social and economic fabric of Sri Lanka over the past few decades, is the increasing proportion of women in the labor market. Females, now comprise 55 per cent of the Sri Lankan workforce (Department of Census and Statistics 2000). The empowerment and autonomy of women and the improvement of women's social, economic and managerial status is essential for the achievement of transparent and accountable public and private sectors. An important change in the social and economic fabric of the Sri Lanka over the past few decades is the increasing proportion of women in the labor market. Female now comprise 55 per cent of the Sri Lanka workforce. The empowerment and autonomy of women and the improvement of women's social, economic and managerial status is essential for the achievement of transparent and accountable public and private sector. The balance of female and male leadership positions remains unequal although the advantages and opportunities for females continue to expand. In other words,

gender differences in the level and type of formal education and in participation in the labour force are rapidly disappearing; but the rate of the advancement of women into higher positions in organizations is relatively slow. The rate at which women are ascending the corporate ladder to upper level leadership positions is confoundedly slow (ILO, 1998). Generally speaking, a growing number of women occupy managerial positions, but at top levels still very few women are present (ILO, 1998).

As the bias of organizations to incorporate female leadership decreases, an inquiry of the attitudes and perspectives of female leaders becomes pertinent in order to understand the organizational situation and culture, personal characteristics, leadership styles and the behavior of successful female leaders. Although the glass ceiling is an obstacle to women for career advancement, some women have successfully climbed the corporate ladder to the upper echelon despite this barrier. Theory maintains that organizational situation and culture, personal factors and leadership styles are important aspects of ascending the corporate ladder. However, the question remains whether the 'feminization of management' will lead to a larger proportion of women in management positions. The following sections (1.1 and 1.2) would discuss the current situation about the participation of women in management in public and private sectors in Sri Lanka.

1.1 Women in Management at the Public Sector

Public sector employees can be divided into three sectors according to the classification of Department of Census and Statistics.

- State sector-includes all the ministries and departments which come under the purview of the central government.
- Provincial public sector-includes ministries and institutions functioning under the provincial councils.
- Semi-government sector / Statutory Boards.

In Sri Lanka, an examination initially in London and subsequently in Colombo was held to recruit to the prestigious Ceylon Civil Service (CCS) which was converted into the Sri Lanka Administrative Service (SLAS) in 1963 and opened to women. The introduction of free education in 1945 in Sri Lanka has ensured men and women equal access to primary, secondary and tertiary education. Higher education has opened up the doors for women to enter higher levels of employment in the variety of areas of public sector. More women than men have been entering Universities since 1996 (University Grants Commission 2000). However, the current literacy rate of 84 percent for Sri Lanka women is among the highest in the world and is nearly twice the average of 48 percent estimated for low-income countries (Jayaweera 2002). More women obtain the necessary qualifications to move up to decision making positions in the country. The proportion of women in government service increased from 26 per cent in 1985 and to nearly 38 percent in 1990. However, in this period nearly 58 percent of female government servants fall under the occupational category of professionals, which include teachers, nurses, midwives etc (Economic and Social Commission for Asia and the Pacific, 1997).

However, women's representation in decision making position such as senior officials, and managers in the public, provincial public and semi government sectors have respectively risen to 25.9%, 23.5% and 22.1% by 2002, so that around 75 of decision makers in the country have been men over that time. The first woman secretary was appointed only in 1995. The percentage of women District Secretaries decline to 8% in 2007. The percentage of Divisional Secretaries rose from only 1.6% in 1993 to 22.9% in 2006 (Sri Lankan Women: Partner in Progress 2007). The percentage of women in the Sri Lanka Administrative Service (SLAS) class 1

gradually increased from 1.8% in 1979 to 27.2% in 2007, only 8.9% of the secretaries are women (The Sri Lankan Women: Partner in Progress 2007). In the Sri Lanka Overseas Service three women ambassadors and one women high commissioner were headed in 2007. In Sri Lanka's Planning Service, the first women reached class 1 only in early 1990 s. The women in the class 1 in the Sri Lanka Scientific Service in 2006 were only 9.8%. Among the senior health administrators, 23.9% were women in 2003. In the Ministry of Education in Colombo, 25.5% of those in senior positions were women in 2005. This included the Senior Assistant Secretaries, Chief Commissioner / Additional Chief commissioners and Directors. In 2004 70% of teachers were women. Only 27.4% of members of the Sri Lankan Principal Service and 17.6% of the heads of the National Colleges' of Education were women. In Sri Lanka's Agricultural Service there were 16.6% in class 1 in 2006. Sri Lanka's Engineering Service 17.1% in class 1 in 2002 and in Sri Lanka's Inland Revenue Service 22.8% in class 1 in 2002. There were 15.3% in Sri Lanka Accountants Service in class 1 in 2006 (Changing Role of Women in Sri Lanka, 1997 Census of Public Sector and Semi-government Sector Employment 2002,2005). Judiciary Service too were only 8.2% of the judges of the Supreme Court, Appeal Court and High Courts, were women in 2000.

1.2 Women in Management at the Private Sector

Research that proved as to why women fail to reach high decision making positions noted that socialization process influencing the occupational choices of women (Gunawardena and Lekamge 2002), gender discrimination, work culture, and the operation of the 'glass ceiling', especially in the private sector, women's role expectations and social practices that place a higher value on the career of a male than that of a female. The private sector has grown parallel to the public sector and has expanded since 1978 after Liberalization of the economy. According to the employment survey of the Department of Labor in 2005, the distribution of private sector employees by occupational groups indicated that only 1.3% of women employees and 5.6% of men employees were in administrative and managerial positions.

The Handbook of Listed Companies: 2005 published by the Colombo stock exchange in 2006 includes details of 233 establishments in 20 'sectors'. Accordingly in the banking, Finance and Insurance (19), Beverage, Food and Tobacco (8), Chemicals and Pharmaceuticals (2), Construction and Engineering (5), Diversified Holdings (2), Footwear and Textiles (0), Health care (8), Hotels and Travels (21), Information Technology (0), Investment Trusts (0), Land and Property (13), Manufacturing (9), Motors (4), Oil Palms (0), Plantations (4), Power and Energy (0), Services (2), Stores and Supplies (2), Telecommunications 1 and Trading (6) there were representation of women in Boards of Directors of Large establishment in Private Sector. Compared with the total number of establishments, the total number of directors were 1750 and numbers of women directors were 106. Accordingly the percentage of women directors were 6.1%. Research on women in private sector leadership has been limited by the same conditions as those found for women's leadership in general; that being the lack of focus exclusively on the president/ CEO position, the lack of consistent methodologies, and the use of non-homogeneous organizations and non-equivalent leadership roles/positions affecting generalizability across contexts and leaders.

2. Research Questions

The problem identified show that, the gender differences in the level and type of formal education and in participation in the labour force are rapidly disappearing (Jayaweera 2000): but the rate of advancement of women into higher positions, in organizations is relatively slow. Even though there is an increasing number of women who enter the workforce and an increasing number of managerial positions women's access to leadership positions remains limited (Eagly et.al, 2003). Accordingly, this research examines the following research questions.

1. What are the perceived barriers that inhibit the career development of women managers in Sri Lanka?
2. What are the policy measures that could be taken to overcome these barriers?
3. How managerial positions in public and private sectors should be distributed across male and female employees?

3. Objectives of the Study

The problem of the glass ceiling that the women management face and the invisible barriers that prevent them from advancing to higher levels of the managerial ladder in most countries of the world, have been analyzed and discussed extensively in a large number of research articles (ILO,1998). The gendered analysis of organizational cultures is considered, as reasons are sought for the higher representation of women in public sector, as compared with private sector management. The female participation rate in the public and private sector labour force in Sri Lanka has increased from 55.1 per cent in 1990 to 53.0 percent in 2011 (Department of Census and Statistics 2011). Despite such economic achievement, relatively little research has been done on the status of women, the general working environment of women in management, wage differentials, personal differentials, sexual segregation, discrimination, and perception and attitudes towards women as managers, etc. Based on this, the general objective of this study is *'to explore the barriers that impede career development of Sri Lankan women managers in public and private sectors'*. Accordingly the specific objectives of the study can be indicated as follows.

While the metaphor of the 'glass ceiling' helps explain why women have poor representation in the power, leadership and decision- making arenas, it does not explain why a 'glass ceiling' actually exists. A number of explanations have been offered, for example, structural factors in organizations and women's personal aspirations and management styles (Still 1994). The study deals with the issue from a number of perspectives; organizational, managerial and personal. Based on this, one specific objective to be examined in this research is '*to construct a theoretical framework to study the significant factors which affect the career advancement for top level women managers'*.

The sex segregation has been a remarkably stable feature of the Sri Lankan workplace during the year 1980, 1985, 1990 and 1998. The index increased from 37.24% to 48.12% between 1990 and 1998 (Department of Census and Statistics 1980, 1985, 1990 and 1998). This index shows that, the job opportunities in top level management positions have not been distributed among males and females, equally. Therefore, another specific objective can be derived as '*to understand the factors which affect to the sex segregation in the managerial positions of public and private sector organizations in Sri Lanka'*.

4. Research Methodology Overview

The research approach for this study was a qualitative method with a feminist orientation for the purpose of describing and exploring women leaders' experiences of their perceived barriers for upward mobility. The intent of the study is to interview purposefully selected 40 women managers in public and private sector organizations in the major cities i.e Colombo, Gampaha, Kandy, Kurunegala and Galle in the occupational categories of Education, Accountancy, Engineering, Insurance, Banking and Medical. To gain these perspectives, qualitative interviews are typically used. The researcher develops semi-structured, open-ended interview questions which provide the participants the opportunity for in-depth discussion. When how and why questions are used, case study, experiments, or histories are appropriate (Yin 2003). The current study is exploratory and uses how and why questions. Yin (2003) posited that when the relevant behavior of the participants cannot be manipulated and contemporary events are examined, case study is the preferred research design; both are conditions of the current research. A Grounded theory data analysis method was used to explore and analyze the interview data to discover the central themes and meanings the women ascribe to their perceived barriers for upward mobility. Analysis of the 254 pages of interview transcripts through open, axial and selective coding yielded a picture of the participant's barriers for upward mobility. As a means of triangulation to ensure research validity (Yin 2003), the women were asked to review the analysis and make comments, edits, and additions to authenticate and validate the analysis used in the final report. The method is designed to give voice to the participating women leaders in the tradition of feminist research perspectives. The sex segregation of decision-makers in public and private sector organizations is assessed by secondary data using the sex segregation index.

5. Limitations

The sample size in qualitative studies typically is small. (Gall, Bory and Gall, 1996). "Qualitative inquiry typically focuses in depth on relatively small samples, even single cases (N=1), selected purposefully" (Patton, 2002). The intent of the study is to interview 40 women managers (20 from each sector) in Public and Private sectors. Due to this small number of participants, there is a concern that the findings may not be comparable or generalizable to the population of all women managers. This study is focused on women and findings are not generalizable to men.

The population of women managers is limited. Especially, in the private sector; therefore this study focused on women managers of six service sectors (Education, Accountancy, Insurance, Banking, Engineering and Medical), where there are more women managers. The findings cannot be generalized for all women executives from other sectors. Another delimitation is inherent in the geographic limitation of the study. The participants were drawn from 5 specific locations (Kurunegala, Colombo, Gampaha, Kandy and Galle) and findings should not be generalized to the entire country. Furthermore, there is a wide range of sizes and types of foundations ranging from one person offices to organizations with large and complex staff configurations. So findings may not be generalizable to highly structured large corporate settings.

Although all research methods have limitations, qualitative findings are highly context and case dependent (Patton, 2002): therefore, the findings may not be genaralizable to a broader population.

Creswell (2003) notes a number of limitations to the use of interviews including, (a) indirect information filtered through the views of interviewees, (b) interviews in a designated place rather than a field setting, (c) possible bias introduced by the presence of the interviewer/researcher, and (d) the fact that people are not equally articulate and perceptive.

The researcher, in qualitative research, is the data collection instrument (Patton, 2002). The researcher's education and experience as well as personal biases, values, attitudes and beliefs enter into the research and pose an intrinsic limitation.

6. Discussion
6.1 Gender Differences in Upward Career Mobility and Sex Segregation
In the emerging realities of globalization and liberal business environment of Sri Lanka, and the influx of women into the labour market, create more opportunities for Sri Lankan women to reach management positions. As a consequence of progressive policies such as free education and the establishment island wide of co-educational schools, over 50 percent of students in secondary schools and universities and 60 percent to 70 percent of those employed in the institutions are girls and women. As a result of these changes, the women in management perform and achieve the barriers to corporate ladder would decrease and new opportunities be created. Therefore, the proportion of women in management of different levels of the organizations has increased. The Department of Census and Statistics (2011) indicate that only around 20 percent of employees who have reached the highest decision making positions in the public and private sector are women. Towards the end of year 2013, the participation of women in decision making at various levels in the public and private sector is very low and the women in the highest management levels have increased only by 20 percent. The sex segregation index value for Administrative and Managerial category has been gradually decreased in last decade. The index took its sharpest drop from 32.2 percent to 21.3 percent between 1996 and 2011. This decrease was primarily due to the increased number of females in Administrative and Managerial category. However, in 2013, index value 21.3 percent indicate that the managerial job opportunities are not being equally distributed among males and females. The study found that smooth progress in upward career mobility was impeded by,
- Cultural factors
- Some adverse factors in the work situation and
- Personal factors.

6.2 Cultural Factors and Women in Management
Corporate culture refers to the values, beliefs and norms shared by organizational members that govern how they behave towards each other and outsiders. Organizational culture or 'the way we do things around here' influences what employees can do and how they conceptualize, define, analyze and address. Sex roles and norms have long been visible in Sri Lankan society. Men are typically raised to be aggressive and independent, while women are raised to be more social and dependent. A woman's primary duty is at home and a man's is at work. Child-rearing, home-making and domestic organizing are a woman's primary responsibilities. In organizational context women are expected to behave like men and to conform to the male norms in the business world. These masculine traits pose a major barrier to women. Industrialization and urbanization, democratic principles and legislative change, the influence of the west and the shrinking globe have brought about many and varied changes in Sri Lankan society. These changes manifest themselves variously. Parents encourage their daughters toward higher education and want equal employment opportunities for them. Socially, women are rejecting traditional paradigms for western ones-choosing their own mates, opting out of unsatisfactory marriages, staying single and changing the role they play in the home. It is argued that the education, occupation and income of the family have a considerable impact on women

being educated and taking up employment. Being a professional woman, brings with it financial independence that contributes to a woman's confidence and self-esteem, and recognition within the community and family.

However there are formidable barriers of entry for women into professional careers. Those who do gain access, are often segregated in female occupations, delegated to lower ranks in organizations, and barred from moving up the hierarchy because the promotion criteria are conditions they cannot meet. Accordingly this study has sought to probe the perceptions of Sri Lankan women managers regarding the impact of organizational culture on their career advancement.

Before discussion can begin, it is important to define what is meant by a 'Cultural Dilemma'. A 'cultural dilemma' exists when something is not part of, or presents a threat to, the established order, meaning, values etc. of an organization, society or nation. Translating this definition into acceptable organizational terms, it means managing the 'inclusion' of previously excluded individuals such as women and ethnic minorities so that the dominant culture, or accepted ways of doing things, is not altered in any way. In other words, the existing paradigms or status quo continue to exist because the 'outsiders' learn to adapt to the prevailing culture in order to both function, and to be accepted, even if only in a cursory way. However, women become especially threatening to men as they near senior management because they are perceived to want to change the dominant culture whether or not this is so. There is no doubt that organizational cultures are essentially gender biased. All organizations embody a male managerial culture because, when both organizations and management systems were first formed, only males were in the workforce. Despite the advent of women into both the workforce and management, and the introduction of anti-discrimination, equal opportunity and affirmative action laws, there have been little fundamental changes to the underlying culture. Accordingly it can be concluded that the organizational culture affects the women to go to top positions in management hierarchy. Organizational culture hasn't changed significantly to accommodate women as a working force. Therefore organizational culture has changed to encourage the women participation in managerial positions.

6.3 Situational Factors and Women in Management

The term 'organizational climate', is commonly used in the literature to refer to prevailing corporate perceptions of women's professional capabilities and commitment to their career. It also includes attitudes towards women that could result in unsupportive and discouraging work environments. Given that women are reported in the literature to be often subject to negative attitudes and stereotypes at work questioning their participation, contribution, commitment and capabilities, the literature suggests that organizational situation is a barrier to women's advancement. Little research has been done on the status of women and the general working environment of women in management, wage differentials, sexual segregation, discrimination and perception and attitudes towards women as managers. Therefore in this research it has tried to understand and include organizational working environment (wage, sexual segregation, discrimination), negative perception and stereotypes, commitment to career constitute (recruiting, selecting, promoting, training and compensating managers), co-operation as a team, lack of support by people, negative attitudes towards women, pay attention for what women managers say at meetings, coping with new technology and organizations encouraging women for leadership positions as the situational factors.

According to the study it was found that there were no wage differentials in male and female salary scales at the managerial level, so that this level there was generally equall pay for work of equal value. However most of them agreed that male and female in the same category in top positions of the private sector are receiving higher salary than public sector. The interviewees reported at least one specific incident in which they

encountered discriminatory behavior. Women still face discrimination and are not equally represented in managerial positions especially at senior levels. According to the sample, stereotyping is the biggest hurdle for women's advancement to top level administration positions. Gender stereotypes play a major role in long range potential than performance rating, and is the biggest barrier for their advancement to top level managerial positions. Women receive less training and educational opportunities than men at all levels of the organizations. However according to most of the women no discrimination has taken place while hiring. It has found that social stereotype of the manager remains masculine, leading to biased decisions against women when it comes to recruiting, selecting, promoting, training and compensating managers.

According to the findings in this study, around two third of the women have ability to work as a team in their organizations. They are working as a team, sharing the duties and responsibilities. When working in an organization, support of others is an important factor. If not it won't be able to perform own duties. Over study found that half of the managers agreed that women do not get enough organizational support. Most women report satisfaction with existing levels of support, yet more perceive a need for more support in order to successfully manage their role. The interviewees agreed that generally, more Sri Lankan women including themselves are getting education and working outside the home. Although women agreed that societal expectations are changing, several of them expressed reservations that women could easily commit to both family and a career. Women have also become more independent due to financial security. Paying attention to say at meetings is one of the important situational factors for promoting women to managerial posts and remain in such posts. According to the views, fifty per cent agreed that others are listening for their voice. According to the one third of women managers, they are not familiar with technology. It is much difficult to familiarize with new technology. Another one third of the women managers have failed to get familiar with new technology. Another one third of women managers, they are very familiar with technology, especially with computers. However, majority of women stated that they received fewer opportunities for professional development. According to the view of many women managers, there are no separate training in their institution to go to the leadership positions.

6.4 Personal Factors and Women in Management
Personal factors are the common obstacles faced by women when they accede to top positions. Therefore in this research it has tried to understand and include job satisfaction, judgment of women's work performance, accomplishments and efforts to be promoted, professional development at work, domestic responsibilities and double role, number of tasks and the heavy work load, psychological well-being (life satisfaction, psychosomatic symptom, emotional exhaustion), different problems deal, nearest colleagues and friendship, fellow managers and support and loneliness in the job as the personal factors.

However many researchers suggest there are gender differences in job satisfaction (Leung and Clegg 2001, London 1983). However in this study, women in the sample appear to be highly motivated and highly committed to their careers. Research has found that women reporting higher levels of job satisfaction in both extrinsic and intrinsic features. It was observed that, the judgments of top level management are given equally and fairly for the women officers when evaluation of performance is done. Promotion is an important matter to almost all the women in the sample. According to the agreement of thirty five women, 'accomplish more and push hard' is not applicable for that purpose. Women advancement to top management is directly related to their increased knowledge and skills and professional development opportunities made available to them

throughout their careers. The eighty per cent of women managers considered that the opportunities for professional development made available in the context of their organizations were adequate.

The expectations and values in workplace cultures may conflict with the values and expectations of work and family for Sri Lankan women. However domestic and motherly responsibilities do not indirectly affect the career progression of women managers by causing delays in obtaining qualifications in the sample. As per twenty two of the women however much the work load is, they try their best to obtain the qualifications required for their career progress. According to 55% of them they did not receive more organizational support in order to manage their professional work and their domestic responsibilities. According to 90% of the women interviewed, number of tasks and the work load is much more. This situation has been indirectly affected for their career development. All agreed that, even though the work load is high, it has not greatly affected to their health. It was observed that women managers interviewed are in good psychological well-being. They have to deal with variety of problems when they are performing their duties. They are carrying on their duties solving the problems they face.

Nearest colleagues and friendship are essential when doing a job. The answer given by one fourth of the women managers were that, even though, there are some problems with peer groups, work is carried out in a cooperative manner. According to another two fourth, there is no any friendship with nearest colleagues. However, according to another one fourth of women managers, they associate with nearest colleagues as friends to delegate some duties and solve some problems. Fellow managers and support is also an important aspect when doing a job. According to one third, support is given by fellow managers and according to two third fellow managers aren't meeting regularly. Therefore their support is in a minimum level. Accordingly, one second of the women in the sample feel alone while the other does not.

6.5 Gender Differences in Managerial Effectiveness

The current results have relevance to the debate about why more women are not advancing in organizations. According to the literature, several researchers have argued that there are multiple factors influencing women's advancement through an organization. These included gender-related as well as structural opportunities, values of the organization, and organizational interpersonal and individual factors and attribution of success to their own ability. The current results would seem to indicate that what female managers do and their effectiveness do not generally distinguish them from their male colleagues. There are eight roles that have been taken to consideration. They are innovator, broker, producer, director, co-ordinator, monitor, facilitator and mentor.

The female managers agreed that they displayed four roles significantly more than did their male counterparts. The roles were innovator, co-ordinator, monitor and mentor. Female managers indicated that they were more effective in their roles than the male managers. Staff of the female managers agreed that their managers displayed five roles significantly more than did staff of the male managers. The roles were innovator, producer, broker, director, co-ordinator and mentor. The staff did not agree any significant difference in the level of effectiveness of their manager. Bosses of the male and female managers did not perceive any significant difference in the roles they displayed or their level of effectiveness. Peers identified two roles where there were significant differences between male and female managers. They are broker and mentor and in both cases they were displayed more by the female managers. Peers indicated that female managers were significantly more effective than male managers. There were some similarities in the perceptions of the three groups, manager themselves, staff and peers. Mentor was identified by all three and co-ordinator by the

managers themselves and their staff. The female managers and their peers also regarded the female managers to be more effective than did the male managers and their peers. It has been found that the women managers and their peers agreed that female managers were more effective than male managers.

6.6 Leadership Behaviour and Leadership Styles

The interviewees in this exploratory study were part of a new wave of Sri Lankan women who practice a non-traditional management style. The research revealed that if the female are given equivalent levels of responsibility within the organization women did not exhibit more traditionally female attributes. Their leadership style differs from the traditional command and control style. Women's management style is centered on communication. They share power and information. These findings were confirmed in our study. They have good listening skills, maintain an open door policy, discuss problems as they arise, and keep everyone informed. According to the research, nonabrasive problem solving found substantial agreement among the women handling problems quietly and without shouting: being assertive with others as necessary and working effectively with difficult people.

Women are better motivators than males. Women managed effectively using influencing skills rather than authority, giving performance feedback and setting clear direction. This study looked at a number of different aspects of supporting employees and found that women's style shared more a common the supportive and participative style. They are friendly, helpful and supportive of employees, understand people's work problems as well as personal problems, and respect each individual. They know how and when to delegate work, holding people responsible for tasks as a modern trend, being organized and attentive to details of the job, and making sure that people understand tasks and appropriate behavior. All of the women managers in the sample have agreed on staff training to encourage employees and assume responsibility to discuss problems and to improve their skills. According to the findings it was found that women leaders coach and develop subordinates and organize and monitor other's works. Women motivate others by transferring their self-interest in to the goal of the organization. Women leaders develop and motivate employees. These leaders believe that people perform best when they feel good about themselves and their work, and they try to create a situation that contribute to that feeling. However, their style of human relationships and their sensitivity and help in employees problems are characteristically Sri Lankan. However, there were not to be seen the difference between their management behavior and it proved that the management styles of women do not affect the sex segregation in management position in the public and private sector organizations.

6.7 Possibilities for Gaining Prominence at Higher Positions in Public and Private Sectors

While women generally continue to be under-represented in top management positions, particularly in the private sector, the executives in this study celebrated their achievements and their contributions to management. It can be seen that the female participation to the total employees has increased from 1990 to 2011. However, the total female workers show a proportion decrease during 1991 to 2006 (Department of Census and Statistics 1990-2009). Decreasing trend is observed in the percentage distribution of public sector female workers during the period concerned and an increasing trend is observed in the percentage distribution of private sector female employees during this period. Privatization of state industries led to the retrenchment of female workers. Females in Administration and Managerial workers category has been increased from 17.8 percent in 1996 to 28.7 percent in 2011 (Department of Census and Statistics, 2011). In year 2000 while women's share in total employment was around 47 percent their share as Administrative and Managerial

workers at just over 20 percent was less than half of this proportion (ILO, 2004). Women in Administrative and Managerial worker category have been increasing gradually. However still their presence was limited to decision making positions. This study suggests that both public and private sectors in Sri Lanka are sites of hope for advancement, but perhaps for different kinds of women. In the public sector, the 1978 constitution is coupled with a commitment by women senior executives to support and build the confidence of staff. In the private sector there was a targeting of individually talented women, who demonstrate confidence and ambition, as well as being blatantly high achievers. There is still a need to push for equal representation of women in top management positions in both sectors. In effect; the major factors that have emerged in the study as constraint to upward mobility particularly of women are cultural, situational and personal.

According to the research framework found in the field, there are relationships between situational, cultural and personal factors. These factors are affecting to the gender differences in leadership effectiveness. The gender differences in leadership effectiveness directly affect to the leadership behavior and leadership styles and indirectly affect to the gaining prominence at higher positions in public and private sectors. The leadership behavior and leadership styles directly affect to the gaining prominence at higherpositions in public and private sectors. Another research could be undertaken in the future to ascertain whether this findings are correct.

FIGURE1

A THEORETICAL FRAMEWORK OF THE STUDY OF WOMEN MANAGERS IN PUBLIC AND PRIVATE SECTORS
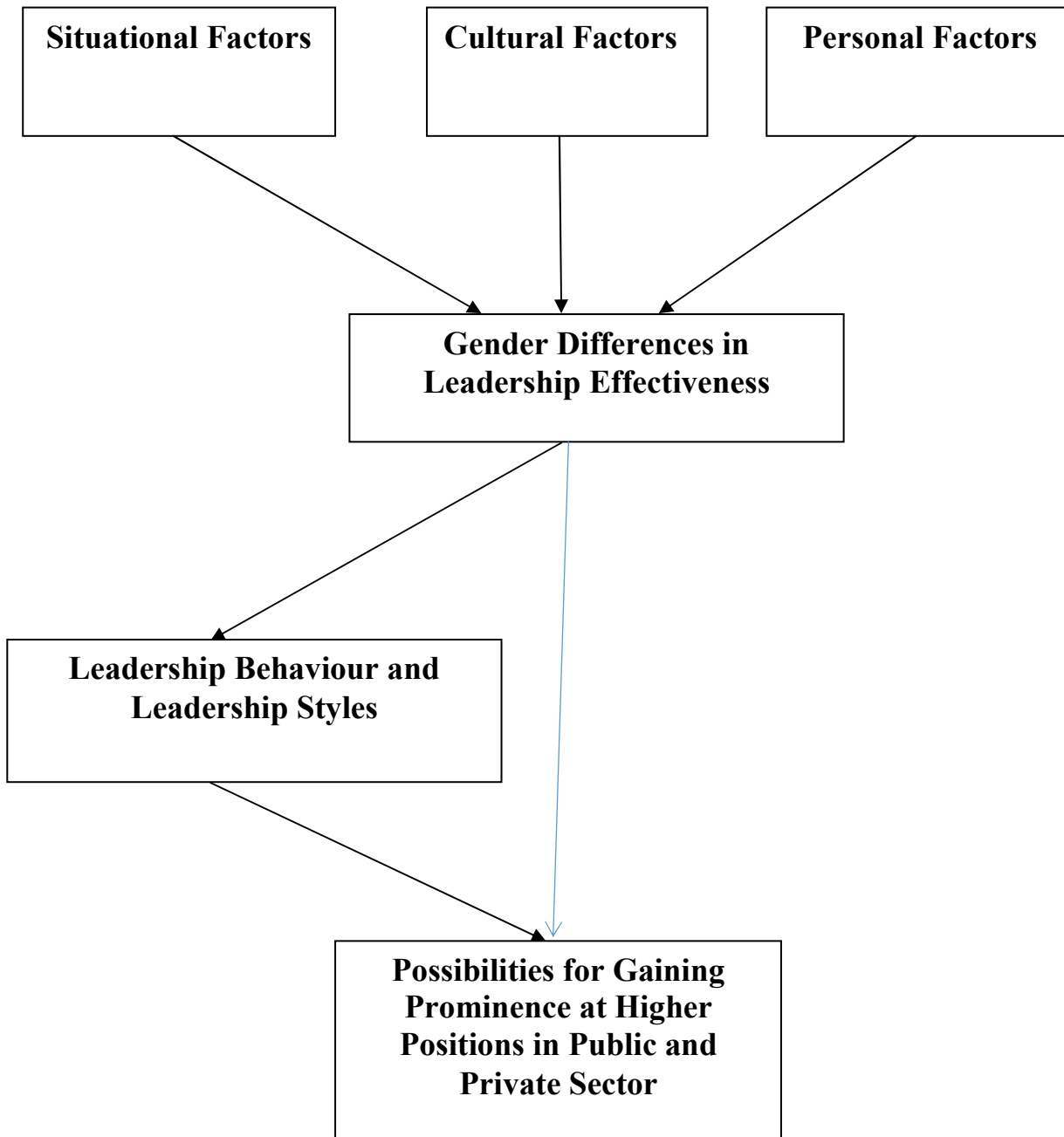
Source- Research Model developed by the researcher.

7. Summary

In this study the first attempts were made to understand the demographic characteristics of women managers and second attempts were made to understand the culture effect on women in management in public and private sector organizations in Sri Lanka. It appears as per analysis data, that organizational culture has thus far been a barrier that has stymied the advancement of women's career and it is a major barrier to women's progress into senior management. Therefore organizational culture has changed to encourage the women participation in managerial positions.

Thirdly, an examination was made to verify the situational factors effect on women in management. Accordingly all the women managers stated their different views. Similarly they agreed on organizational working environment, negative perception and stereotypes, commitment to career constitute, lack of support by people, pay attention to say at meetings, coping with new technology and organizational encourage women for leadership positions as main barriers as situational factors. However to break the glass ceiling, these women had to develop assertive strategies to surmount many impediments and to seek out organizational situation that permitted the career advancement.

Fourthly, an examination was made to verify the personal factors effect on women in management. This study looked at a number of different criteria for managerial effectiveness and found out that there are barriers in organizational support, number of task and working load, nearest colleagues and friendship and fellow managers and support.

Fifth, the study found that the self-perception of all women managers was that the female managers displayed innovator, co-ordinator, monitor and mentor roles more than their male counterparts. It has found that the women managers and their peers reported that female managers were more effective than male managers. However, study confirmed that the cultural, situational and personal factors do not affect the managerial effectiveness of women managers and they have better managerial effectiveness.

It appears as per analysis data that women are more likely to adopt a participative style. They share power and information, are interactive, connective, being assertive as others as necessary, working effectively with difficult people. Employees believing in their own competence and ability to succeed and conveying a positive attitude towards employees and others. Further, it can be seen that they are friendly, helpful, supportive of employees, understand peoples work problems as well as personal problems, respect each individual, know-how and when to delegate work and prioritize staff development. Generally, they do not show dialectical behavior in their managerial positions and use their style in non-traditional manner.

Sixth, there are more women employed as managers in the public sector than in the private sector, findings confirmed that women remain under-represented in top management positions. Cultural, situational and personal factors have affected to these situation. There is still a need to push for equal representation of women in top management positions in both sectors. Finally, in this chapter the theoretical framework behind the study is build, compared and reviewed with prevailing literature.

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