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Meter Calibration under Simulated Process Conditions

by

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INTRODUCTION

Con-Tech a/s is an independent Norwegian company, established in 1985, which have specialised on services within fiscal flow measurement of oil and gas.
In 1991 we established a subsidiary company, Con-Tech UK Ltd, in Aberdeen. Both companies offer the same scope of services.

In 1991 Con-Tech a/s was accredited, by Norwegian Accreditation, for calibration of Pipe Provers over 500 litres with an best uncertainty of ± 0,030%. Equipment to be used for this accredited work is our Compact Prover and Master Meter.

In 1992 we was approached by Statoil with a request for our interest to participate in a evaluation test of Coriolis Meters and to set up a calibration laboratory for this purpose.
The design specification was agreed to be as follows:

- Hydrocarbons to be used as calibration liquids
- Multiple storage tanks for various qualities
- 0 - 400 m^3 / hour as range of flowrates
- 0 - 100 barg pressure range
- 20 - 85 °C temperature range
- Due to the use of hydrocarbons all electrical equipment must be Eex
- Real time data acquisition and computations

In January 1993, 6 months delayed, all equipment was installed and commissioned and the test programme started.

CALIBRATION SET-UP

The calibration loop consists of 3 parallel streams connected to a inlet and outlet header. One stream is 6" maximum and 2 streams is 4" maximum. Each stream have a double block and bleed inlet valve, space for installing a Coriolis Mass Meter (CMM), adjustable points for support, pressure taps before and after CMM, turbine meter with meter run, pressure and temperature transmitters, location for insertion densitometer and outlet flow control valve. Dual Schlumberger Oil Densitometers are located downstream of the outlet header with one pressure and two temperature transmitters. Further downstream is the takeoff to the heat exchangers with a bypass flow control valve. Next comes the variable speed circulation pump before the liquid enters the Compact Prover.
The tie-in for liquid filling and pressurisation is also upstream of the pump.

Signals from CMM's, turbine meters, densitometers, pressure and temperature transmitters are all connected to the Siemens Sicomp process machine. Temperature and pressure on the Compact Prover are logged manually.

The VDU presentation consists of, for every stream, temperature, pressure, volumetric flow rate, mass flow rate from CMM, calculated mass flow rate from reference, density and density temperature and pressure.

The process machine software also have a feature for data sampling and averaging, sampling time selectable by operator.

All data collected during a sampling period can be transferred to the PC for presentation in engineering units. This data file is transferred to a calculation program, developed by Con-Tech, and manually logged data is also entered here.

This calculation program converts Compact Prover volume, volume displaced during meter calibration and density to the conditions at the turbine meter. Hence the calculated accumulated mass or mass flowrate will be at turbine meter conditions and this data is compared to the accumulated mass or mass flowrate from the coriolis meter under test. The density output from the CMM is also compared to our reference densitometers.

As an extra verification of the density, a oil sample is drawn during a test and sent to a laboratory for density and viscosity determination.

Coefficients for oil thermal expansion and compressibility is determined by varying temperature and pressure and then calculate density changes per deg. C and barg. This is checked in the operating range.

CALIBRATION OF GULLFAKS "B" METER RIG.

The Gullfaks "B" Meter Rig is designed to meter unstabilized crude oil coming from the platforms test separator. The Meter Rig will also be used as reference for testing of Multiphase Meters which will be located upstream of the test separator.

The Gullfaks "B" meter rig comprises a 4" Daniel turbine meter with a 3" Micromotion Mass Meter in series. It then splits into two lines where one line have a 2" Schlumberger Mass Meter and the other a water cut meter. There is also provisions for installing an insertion densitometer.

Valve arrangement is such that the 2" Schlumberger Mass Meter or the water meter can be isolated from the oil flow.

The test set-up for these meters and calibration rig was that Gullfaks "B" crude oil entered the Compact Prover from the pump and through a 4" pipe to the GFB rig inlet. The two outlets were routed through a 6" pipe to our metering streams and heaters / coolers.

Temperature and pressure were recorded at GFB rig inlet and outlet. Mass Meter Density signals interfaced through their flow computers to our process machine. Turbine Meter signal interfaced to our Compact Prover Computer and process machine. Temperature and pressure on the Compact Prover were logged manually. Due to interface limitations mass flowrate was read of the instrument's flow computer.

The test programme was set up to be a 5 point calibration over the meters range, or the range achieved with a maximum of 2 bar differential pressure and with the following pressure and temperature conditions:

60 barg and 50 °C
60 barg and 60 °C
70 barg and 50 °C
70 barg and 60 °C

The mass meters was also calibrated on a very low rate of 4 tonnes / hour.
Calibration on every rate and condition should be repeated 3 times.
Zero flow to be monitored for every change in pressure/temperature, but not adjusted.
After completed calibration the CMM's calibration factor should be recalculated and a verification calibration done on one condition, at 3 flowrates.

This all added up to 75 calibration points for each of the CMM's and at least 500 single calibrations of the turbine meter.

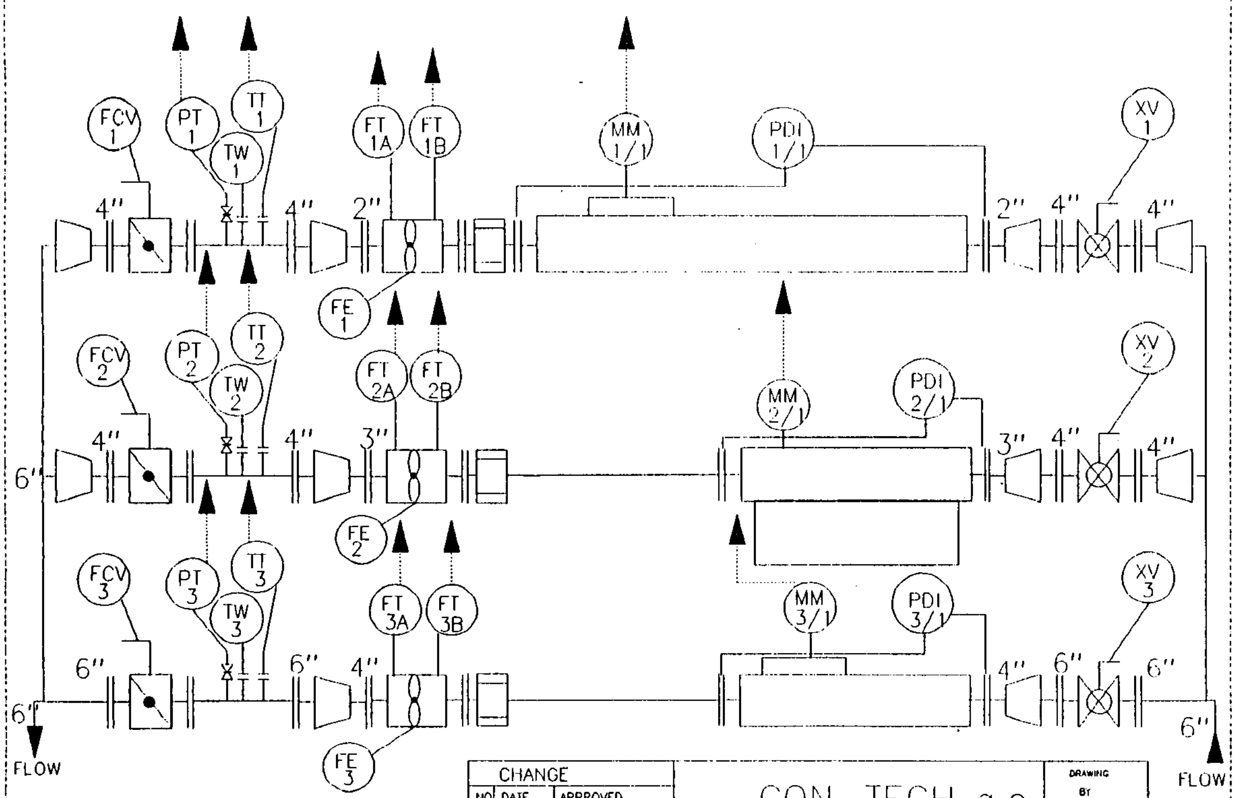
CALIBRATION RESULTS.

Daniel Industries 4" Turbine Meter. (Fig. 1)

The turbine meter is calibrated directly against our Compact Prover.
The curves are drawn with reference to the meter factor obtained in the factory water calibration.
Every point is the average of 25 single calibrations with a repeatability of < 0,025%.
The flowrate through the turbine was maximum 130 m^3/hr due to loop pressure drop.
The meter factor is 1,5% lower than the factory calibrated meter factor, when metering crude oil.
Temperature sensitive at 70 barg and at the lower flow rates.
Meter linearity at 50C/70bar is ± 0,6 %.
Not able to trace down reasons for change in meter factor on 50C/70bar, lower rates. The 2" Brooks Reference Meter gave similar results.

Micro Motion 3" Coriolis Mass Meter. (Fig. 2)

Maximum flowrate 112 tonne/hour with 2 bar pressure drop. Density 0,874 kg/l, viscosity 7,4 cSt/40C.
The curves are drawn with reference to calculated mass flowrate from our calibration equipment, rate averaged over 5 minutes.
Repeatability on 3 tests < 0,1%.
Our master meter, 4" or 2" Brooks Turbine Meter, was calibrated against the Compact Prover just prior to comparison test, repeatability better than 0,020%, minimum 25 single calibrations.
Displayed rate is 1,5% lower than factory calibration, when metering crude oil.
No obvious sensitivity to varying pressure or temperature.
All points within a range of ± 0,55%. Linearity at 60C/60barg ± 0,35%.
Verification test gave results within 0,05% of expected.



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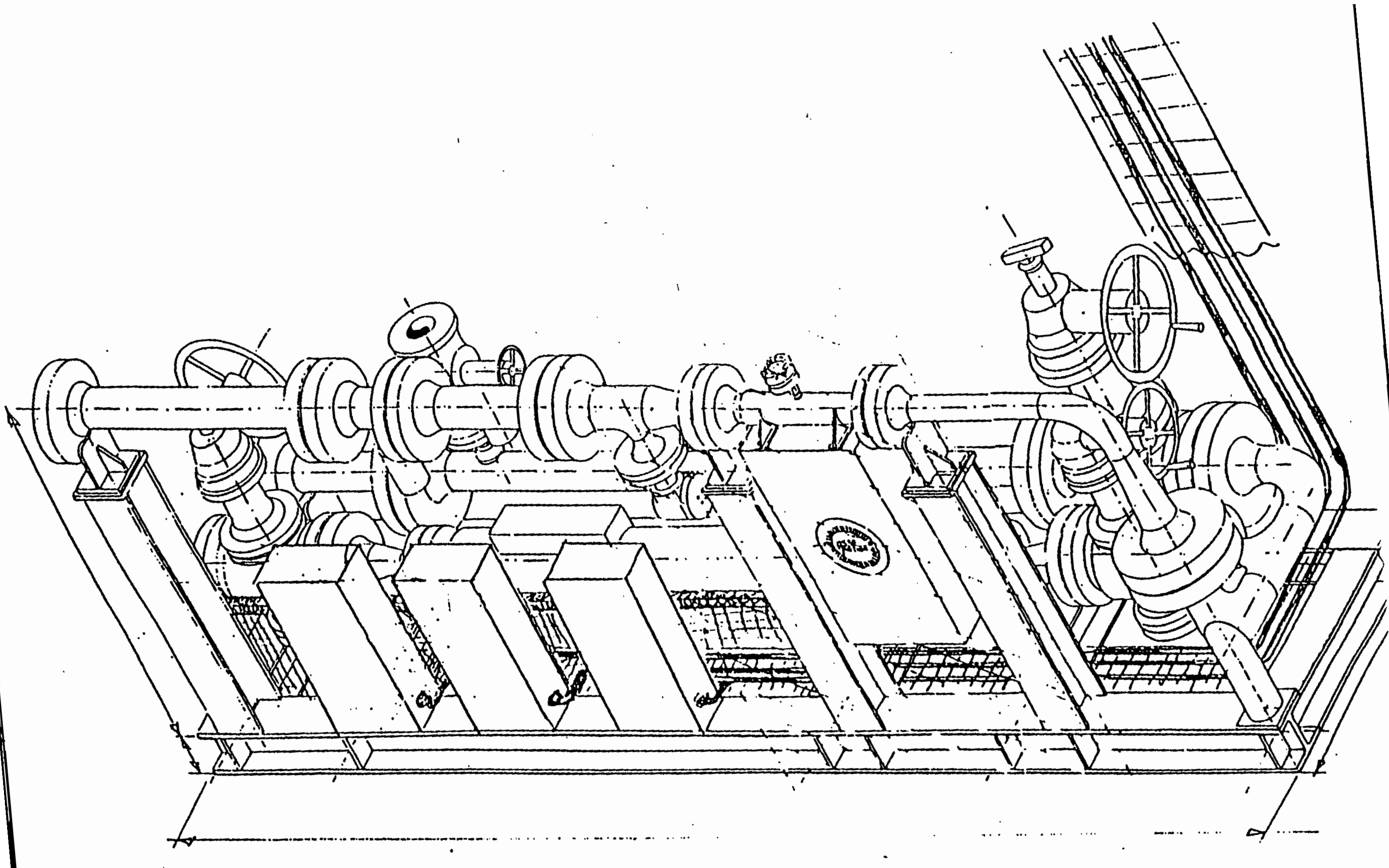

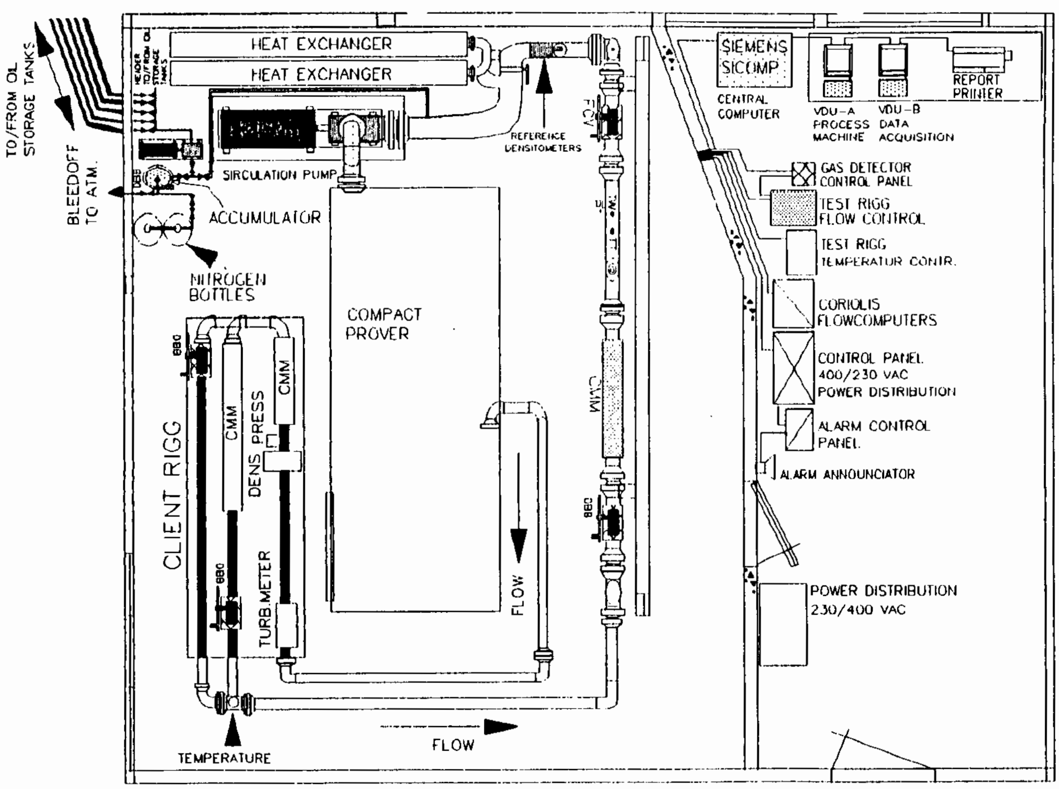

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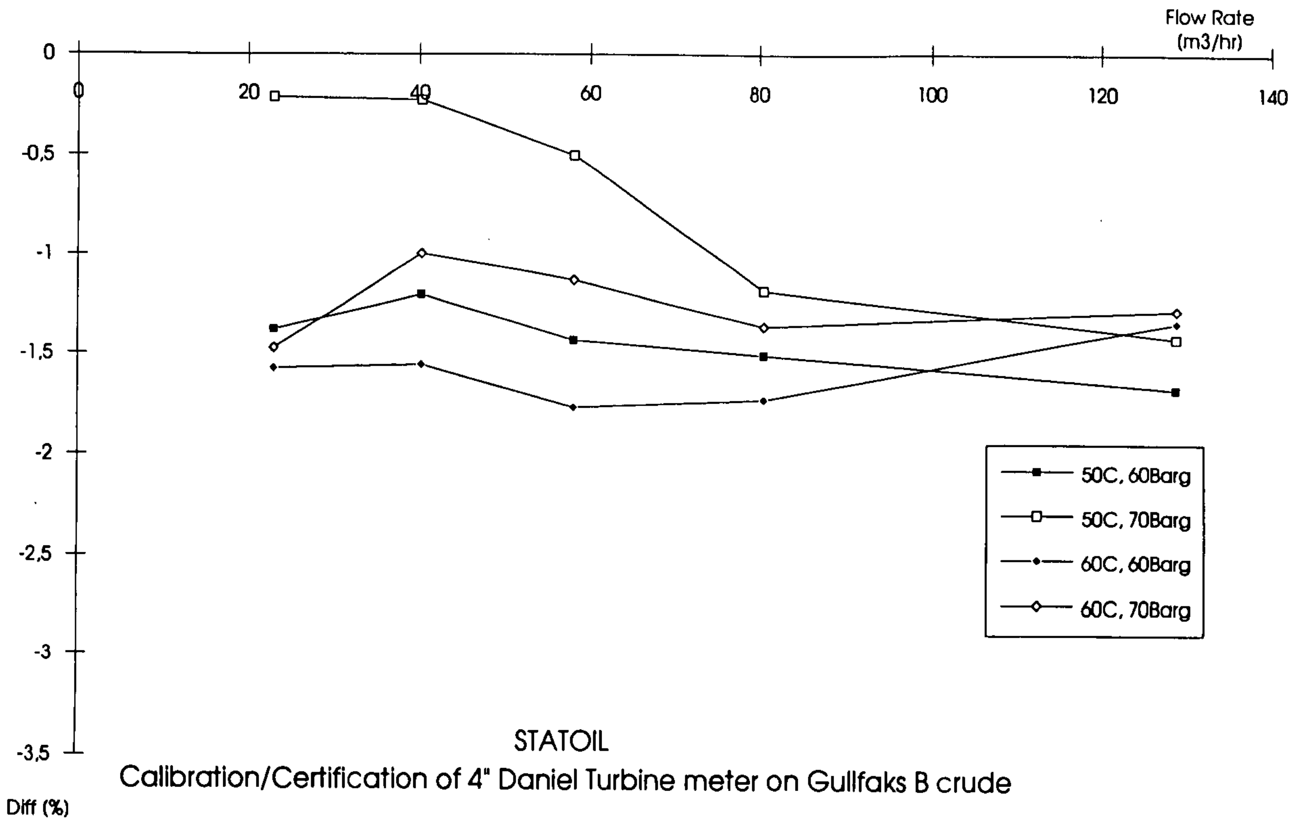

STATOIL

Calibration/Certification of 4" Daniel Turbine meter on Gullfaks B crude

FIG. 1

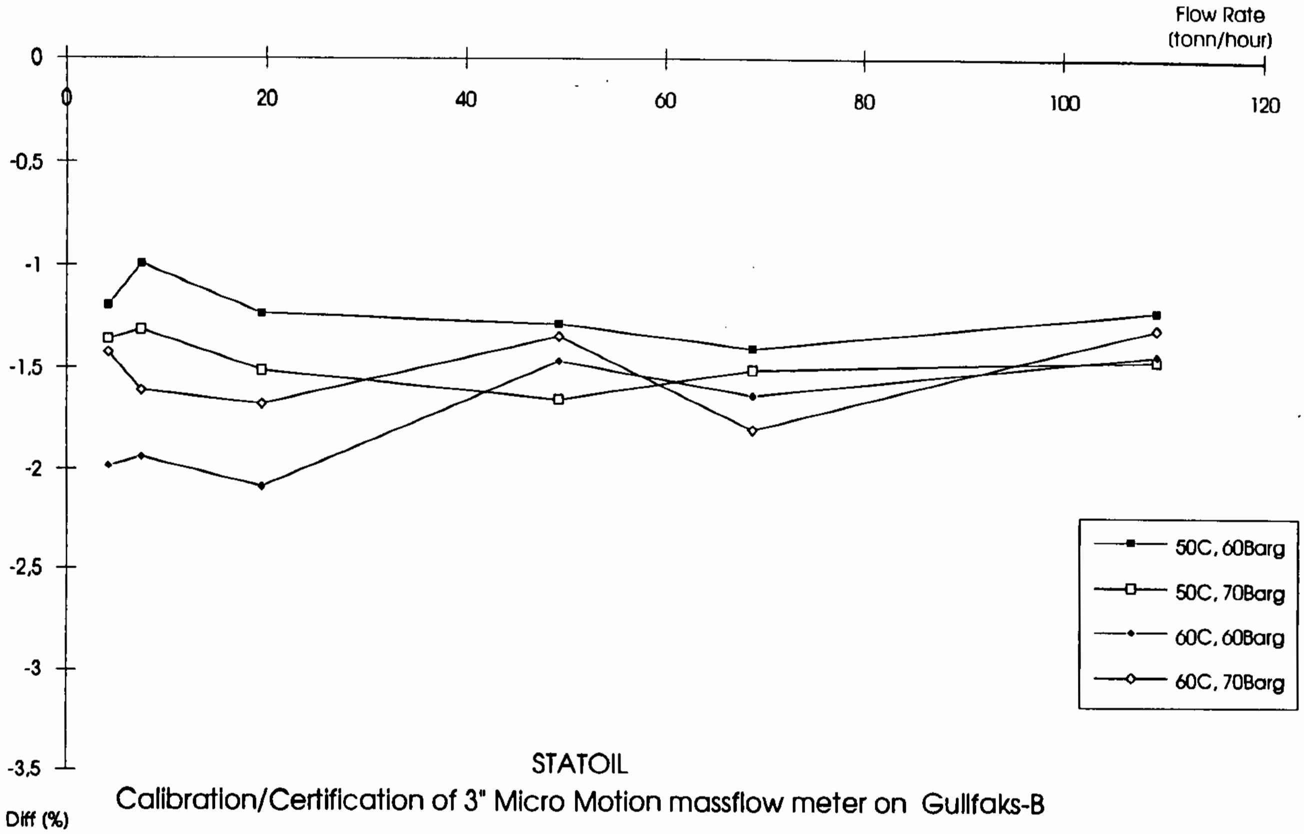
Flow Rate
(tonn/hour)
0
20
40
60
80
100
120
0
-0,5
-1
-1,5
-2
-2,5
-3
-3,5
Diff (%)
50C, 60Barg
50C, 70Barg
60C, 60Barg
60C, 70Barg
STATOIL
Calibration/Certification of 3" Micro Motion massflow meter on Gullfaks-B

FIG. 2

References

[1] Paper presented at the North Sea Flow Measurement Workshop, a workshop arranged by NFOGM & TUV-NEL

Note that this reference was not part of the original paper, but has been added subsequently to make the paper searchable in Google Scholar.