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TOSHKENT DAVLAT TRANSPORT UNIVERSITETI

Tashkent state transport university

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The Journal of Transport showcases groundbreaking scientific and applied research conducted by transport-oriented universities, higher educational institutions, research centers, and institutes both within the Republic of Uzbekistan and globally. Recognized for its academic rigor, the journal is included in the prestigious list of scientific publications endorsed by the decree of the Presidium of the Higher Attestation Commission No. 353/3 dated April 6, 2024. This inclusion signifies its role as a vital repository for publishing primary scientific findings from doctoral dissertations, including Doctor of Philosophy (PhD) and Doctor of Science (DSc) candidates in the technical and economic sciences.

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Articles are published in Uzbek, Russian, and English, ensuring a wide-reaching audience and fostering cross-cultural academic exchange. As a beacon of academic excellence, the "Journal of Transport" continues to serve as a vital conduit for knowledge dissemination, collaboration, and innovation in the transport sector and related fields.

Improving the operational efficiency of freight vehicles through the use of telematics

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Abstract: In this scientific article, a practical-analytical approach to the application of Fuel Level Sensors (FLS) within the framework of Intelligent Transport Systems (ITS) to improve the operational efficiency of freight vehicles along the key highway corridor of the Fergana Valley — the Kokand–Fergana route — is investigated. The study addresses the problem of unreliable fuel consumption monitoring using traditional methods (with high error rates of ±10–20%), despite fuel expenses accounting for 40–60% of total transport costs. The core methodology is based on integrating DUT-E capacitive fuel level sensors (accuracy ≤1%) with a GPS/GLONASS tracker, followed by processing and analyzing the collected data through a cloud-based FMS/Telematics software platform. Practical field tests were conducted using the example of the enterprise "AVTOGIGANT DANGARA" LLC. The results demonstrate that the implementation of the FLS system led to a reduction in driving fuel consumption by up to 6.43% (due to improved driver discipline) and a 33.33% decrease in idling fuel consumption. Additionally, fuel drainage (theft) incidents were brought under 100% control and fully prevented. Economic calculations showed that, for instance, the DUT device installed on an ISUZU vehicle pays back within approximately 7 months. In conclusion, the research scientifically substantiates that the DUT/ITS system delivers significant economic benefits for logistics companies.

Keywords: intelligent transport systems (its), fuel level sensor (fls), capacitive sensor, fms/telematics, fuel consumption analysis, Kokand–Fergana route

Yuk avtomobillarida telematikani qo‘llash orqali ulardan foydalanish samaradorligini oshirish

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Annotatsiya: Ushbu ilmiy maqolada Farg‘ona vodiysining muhim magistral yo‘nalishi — Qo‘qon–Farg‘ona oraliqlarida yuk avtomobillari ekspluatatsiyasi samaradorligini oshirish maqsadida Intellektual Transport Tizimlari (ITS) doirasidagi Yoqilg‘i Darajasi Sensorlarini (DUT) qo‘llashning amaliy-analitik yondashuvi tadqiq etilgan. Maqolada transport xarajatlarining 40−60% ini tashkil etuvchi yoqilg‘i sarfini an’anaviy usullar (yuqori xatolik ±10−20%) bilan ishonchsiz monitoring qilish muammosi ko‘tarilgan. Tadqiqotning asosiy metodologiyasi DUT-E Kapasitiv sensorlarini (aniqlik ≤1%) GPS/GLONASS trekkeri orqali birlashtirishga va olingan ma’lumotlarni Bulutli FMS/Telematika Dasturi orqali tahlil qilishga asoslangan. Amaliy sinovlar "AVTOGIGANT DANGARA" MChJ korxonasi misolida o‘tkazilgan. Natijalar DUT tizimini joriy etish orqali yo‘l sarfining 6.43% gacha qisqarganini (haydovchi intizomini oshirish hisobiga) va turish sarfining 33.33% ga kamayganini ko‘rsatdi. Shuningdek, tizim orqali drenaj (o‘g‘rilik) holatlari 100% nazoratga olinib, oldi olingan. Hisob-kitoblar, masalan, ISUZU avtobusiga qo‘yilgan DUT qurilmasi ≈7 oyda o‘zini oqlashini ko‘rsatgan. Xulosa DUT/ITS tizimining logistika korxonalari uchun katta iqtisodiy samara keltirishini ilmiy jihatdan asoslaydi.

Kalit so‘zlar: intellektual transport tizimlari (its), yoqilg‘i darajasi sensori (dut), kapasitiv sensor, fms/telematika, yoqilg‘i sarfi tahlili, Qo‘qon–Farg‘ona yo‘nalishi

1. Kirish

Global iqtisodiyotda, xususan, O‘zbekistondagi Farg‘ona vodiysi kabi jadal rivojlanayotgan mintaqalarda logistika va yuk tashish sohasi asosiy iqtisodiy drayverlardan biri hisoblanadi. Transport xarajatlarining katta qismini, ba’zi hisob-kitoblarga ko‘ra 40−60% gacha bo‘lgan ulushini, yoqilg‘i iste’moli tashkil etadi. Shu sababli, yuk avtomobillari parkini samarali boshqarishda oqilg‘i sarfini aniq nazorat qilish va optimallashtirish dolzarb ilmiy-amaliy muammo bo‘lib qolmoqda. [1-8]

Qo‘qon–Farg‘ona yo‘nalishi yuqori yuk aylanmasiga ega bo‘lgan ichki magistral yo‘nalishlardan biridir. Bu yo‘nalishning o‘ziga xos xususiyatlari — kuniga bir necha

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marta reyslar, turli yo‘l sharoitlari (tekislik, aholi punktlari ichi, tirbandliklar) va tez-tez yoqilg‘i quyish zaruriyati — yoqilg‘i sarfida xato va suiiste’mol xavfini oshiradi. An’anaviy hisob-kitoblar (cheklar va standart bort datchiklari) yuqori xatolik (±10–20%) tufayli ishonchli monitoringni ta’minlamaydi. [8-12]

Ushbu tadqiqotda mazkur muammoni hal qilish uchun Intellektual Transport Tizimlari (ITS) texnologiyasining muhim elementi bo‘lgan Yoqilg‘i Darajasi Sensorlarini (DUT) joriy etishga e’tibor qaratilgan. Kapasitiv DUT yuqori aniqlikda (≤1%) ma’lumot beradi, bu esa yoqilg‘i balansini real vaqt rejimida shaffof nazorat qilish imkonini beradi.[13-17]

2. Tadqiqot metodologiyasi

DUT — yoqilg‘i baki ichidagi darajani aniqlovchi sensor bo‘lib, telematik tizim orqali sarfni kuzatishga imkon beradi.

DUT E GSM (fuel level sensor + GPS) imkoniyatlari quyidagilardan iborat:

Bu modelda yonilg‘i darajasini o‘lchash bilan birga, GPS joylashuvni aniqlash va GSM orqali uzatish imkoniyati mavjud

Internet orqali masofaviy sozlash imkonini beradi; yordamchi xodim ofisdan turib sensor parametrlarini o‘zgartirishi mumkin

Sensor real vaqt rejimida 20 tagacha turli analitik hisobotlar (yonilg‘i miqdori, joylashuv, harakat holati, to‘xtash, yonilg‘i to‘ldirish/yuvish holatlari va boshqalar) yaratadi

Suniy telematik serverga ehtiyoj sezmasdan, foydalanuvchiga SMS yoki email orqali hisobot jo‘nash imkoniga ega

Boshqa DUT E CAN yoki 2Bio sensorlarni S6 tarmog‘i orqali jamlab ishlatish imkoniyati mavjud.

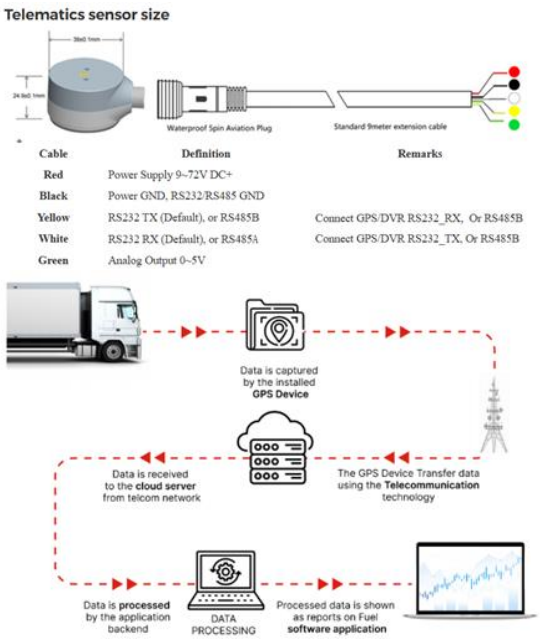
DUT E 2Bio Turli yoqilg‘i turlarida (yozgi, qishki dizel, bio yoqilg‘ilar) aniqlikni avtomatik sozlay olish imkoniyatiga ega, uchinchi elektrodda fuel permittivligini tahlil qiladi va o‘lchovlarni tuzatadi. Aniqligi ~1 %, interfeyslar – CAN, RS 232/485, analog/frequency, quvvat 10 45 V. Batareya bilan ishlaydi, ishlash muddati 5 10 yil (atrof muhit haroratiga qarab) Eksploziv (Ates-zararsiz) muhitda foydalanishga mos, bu sensor uchun EX sertifikatga ega.[18-21]

ITS ning asosiy maqsadi — ma’lumotlarni yig‘ish, qayta ishlash va tarqatish orqali transport tizimini boshqarish samaradorligini oshirishdir. Yoqilg‘i monitoringi ITS ning Avtopark Boshqaruvi (Fleet Management System – FMS) segmentida muhim rol o‘ynaydi, chunki u real iqtisodiy samarani ta’minlaydi. DUT real vaqt rejimida benuqson ma’lumot uzatuvchi asosiy sensor bo‘lib, xatoni 1% gacha kamaytiradi.

1-jadval

Yoqilg‘i monitoringi tizimi bir necha o‘zaro bog‘liq bo‘lgan texnologik bloklar

Blok	Vazifasi	Qo‘llaniladigan Texnologiya
I. O‘lchash (DUT)	Bakdagi yoqilg‘i darajasini yuqori aniqlikda o‘lchash.	Kapasitiv DUT-E (yoki analogi), kalibratsiyadan o‘tgan.
II. Ma'lumotlarni Yig‘uvchi	DUT ma’lumotlari, GPS koordinatalari va bort tarmog‘i (CAN/J1939) ma’lumotlarini birlashtirish.	GPS/GLONASS Trekker (RS-485 interfeysi bilan).
III. Uzatish Kanali	Ma’lumotlarni markaziy serverga real vaqt rejimida yuborish.	GSM/GPRS yoki 3G/4G mobil aloqa.
IV. Tahlil Platformasi	Ma’lumotlarni saqlash, tahlil qilish, hisobotlar va ogohlantirishlar yaratish.	Bulutli FMS/Telematika Dasturi (Analitik modullar).



1-rasm. Ish oqimini monitoring qilish tizimi

Umumiy yoqilg‘i sarfi quyidagi fo‘rmula orqali aniqlanadi:

$$Q = \frac{Q_b}{100} * L \quad (1)$$

Bu yerda,
Q-umumiy yoqilg‘i sarfi (litr)
Qb- avtomobilning 100 km uchun bazaviy yoqilg‘i sarfi
L-bosib o‘tilgan masofa (km)
Yuk ortilgan holatdagi sarfni hisoblash:

$$Q_{yuk} = Q_b * \left(1 + \frac{m_{yuk}}{M_{avto}} * k\right) \quad (2)$$

Bu yerda,
Qyuk-yuk ortilgandagi yoqilg‘i sarfi (l/100 km)
myuk-tashilayotgan yuk massasi (tonna)
Mavto-avtomobilning to‘liq yuk ko‘tarish quvvati
k-yuk ta’sir koeffisiyenti (odatda 0.01-0.03 oralig‘ida olinadi)
Yo‘l sharoitiga qarab tuzatish:

$$Q_{real} = Q_{yuk} * (1 + k_{yo'l}) \quad (3)$$

Bu yerda,
Qreal-real yoqilg‘i sarfi (l/100 km)
kyo‘l- yo‘l va harakat sharoiti koeffitsiyenti: (shahar ichida: 0.10–0.25, tog‘li hududda: 0.15–0.30, magistralda: 0.00–0.10)
Soatlik yoqilg‘i sarfi (dvigatel ishlashida):

$$Q_{soat} = q_{nom} * t \quad (4)$$

Bu yerda:
Qsoat – dvigatel ishlashida sarflangan yoqilg‘i (litr),
qnom – dvigatelning soatlik yonilg‘i sarfi (l/soat),
t – ishlash vaqti (soat).

3. Natija va muhokamalar

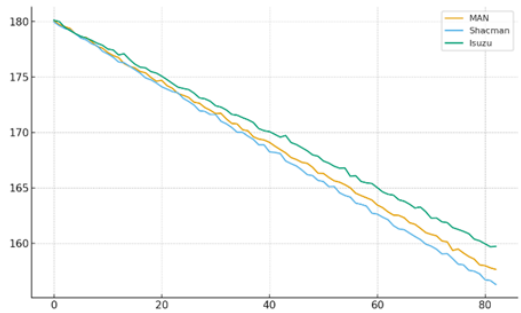
Tadqiqotning metodologik qismida belgilanganidek, Qo‘qon–Farg‘ona yo‘nalishida harakatlanuvchi “AVTOGIGANT DANGARA” MChJ qarashli yuk avtomobilida DUT tizimi monitoringi o‘tkazildi. Olingan natijalar yoqilg‘i sarfini aniq tahlil qilish, noqonuniy yo‘qotishlarni bartaraf etish va operatsion samaradorlikni oshirish bo‘yicha muhim ko‘rsatkichlarni taqdim etdi.

2-jadval

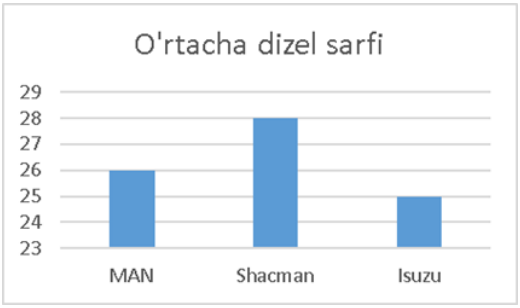
“AVTOGIGANT DANGARA” MChJ avtoulovlarga 2025-yil 4-oyi mobaynida dizel yonilg‘isi sarflanganligi tahlili

MAN avtoulovi (100 kmga taxminan 27 litr dizel yonilg'isi sarflaydi)						
Oylar	2024-yil		2025-yil		2024 y.ga yurgan masofasi farqi ± km.	2024 y. ga nisbatan yonilg`i sarfi farqi ± litr
	Bosib o‘tgan km.	Yonilg`i sarfi litr	Bosib o‘tgan km.	Yonilg`i sarfi litr		
Yanvar	51215	4711	48008	4416	-3207	-295
Fevral	48416	4454	45905	4223	-2511	-231
Mart	49901	4590	46812	4306	-3089	-284
Aprel	49920	4592	43983	4046	-5937	-546
Jami	199452	18349	184708	16993	-14744	-1356
2. Shacman avtoulovi (100 km.ga 29,3 litr dizel yonilg'isi sarflaydi)						
Oylar	2024-yil		2025-yil		2024 y.ga yurgan masofasi farqi ± km.	2024 y. ga nisbatan sarfi farqi ± litr
	Bosib o‘tgan km.	Sarfi litr	Bosib o‘tgan km.	sarfi litr		
Yanvar	9196	313	8966	306	-230	-8
Fevral	10315	352	10103	344	-212	-7
Mart	9700	331	9467	323	-233	-8
Aprel	10190	347	10002	341	-188	-6
Jami	**39401**	**1345**	**38538**	**1315**	**-863**	**-29**
3. ISUZI AVTOBUS avtoulovi (100 km.ga 18 litr dizel yonilg'isi sarflaydi)						
Oylar	2024-yil		2025-yil		2024 y.ga yurgan masofasi farqi ± km.	2024 y. ga nisbatan sarfi farqi ± litr
	Bosib o‘tgan km.	Sarfi litr	Bosib o‘tgan km.	sarfi litr		
Yanvar	7784	1395	6745	1216	-1039	-179
Fevral	8394	1512	6670	1202	-1724	-310
Mart	6251	1126	6365	1126	114	0
Aprel	7369	1326	6539	1177	-830	-149
Jami	**29798**	**5359**	**26319**	**4721**	**-3479**	**-638**

Bu tahlildan MAN yuk avtomobiliga qo‘yilgan Omnicomm LSS 5 1000 мм markali DUT qurilmasi taxminan 1 yilda o‘ziga sarflangan pulni oqlashini ko‘rishimiz mumkin. Shacman avtoulovining tahlili shuni ko`rsatadiki, o‘tgan yilning boshlang‘ich 4 oyiga nisbatan bu yil 863 km kamroq bosib o`tilgan. Bu esa 29 litr dizel yonilg`isini tejash demakdir. Shacman avtouloviga qo`yilgan Omnicomm LSS 5 1000 мм markali DUT qurilmasi taxminan 1 yilda o‘ziga sarflangan pulni oqlashini ko`rishimiz mumkin. ISUZI avtobusining tahlili shuni ko`rsatadiki, o`tgan yilning boshlang`ich 4 oyiga nisbatan bu yil 3479 km kamroq bosib o`tilgan. Bu esa 638 litr dizel yonilg`isini tejash demakdir. ISUZU avtouloviga qo`yilgan Omnicomm LSS 5 1000 мм markali DUT qurilmasi taxminan 7 oyda o‘ziga sarflangan pulni oqlashini ko‘rishimiz mumkin.



2-rasm. MAN, Shacman va Isuzu yuk avtomobillarida yoqilg‘i darajasi o‘zgarishi



2-rasm. MAN, Shacman va Isuzu avtomobillarining o‘rtacha dizel sarfi solishtirilishi

Yuqorida ko‘rsatilgan afzalliklaridan tashqari DUT tizimining ba‘zi kamchiliklari ham mavjud. Misol tariqasida DUT tizimining narxini keltirib o‘tishimiz mumkin. Hozirgi kunda 1 dona Omnicomm LSS 5 1000 мм markali DUT qurilmasining narxi o‘rtacha 250$ ni tashkil qiladi. Bu ko‘pgina korxonalarga o`z avtomobillarini DUT qurilmasi bilan ta‘minlashda muammolar yuzaga keltiradi. Bundan tashqari, avtomobillar tunellar, yerto‘lalarda harakatlanganda DUT qurilmasi orqali aniq ma’lumotlar uzatishda muammolar yuzaga kelishi mumkin. Bu esa yuqori samaradorlikka o‘z ta’sirini o‘tkazadi.

GPS qurilmasining amaliy ahamiyatini “AVTOGIGANT DANG‘ARA” MChJ misolida ham ko`rishimiz mumkin. Bu korxonada jami 10 ta avtomobil mavjud bo`lib, shulardan 7 tasi yengil (Matiz, Nexia, 3 ta Damas, 2 ta Toyota), 2 tasi tirkamali yuk avtomobillari (MAN va Shacman) va 1 ta ISUZI avtobusi hisoblanadi. Yuk avtomobillarning barchasiga 2024-yil yanvar oyida Omnicomm LSS 5 1000 мм markali DUT qurilmasi o‘rnatilgan.

Tahlillar shuni ko`rsatadiki, joriy yilning boshlang‘ich 4 oyi davomida “AVTOGIGANT DANGARA” MChJ korxonasidagi yuk avtomobillarga qo‘yilgan Omnicomm LSS 5 1000 мм markali DUT qurilmasi qo`yilishi natijasida transport vositalari o`tgan yilning shu davriga nisbatan qariyb 14744 km masofa kamroq bosib o`tgan. Bu esa deyarli 1356.5 litr(m3) yonilg`idan tejash demakdir. Bu esa korxona budjetiga taxminan 8 139 000 so‘m foyda keltirgan.

3-jadval

DUT joriy etilgandan so‘ng olingan o‘rtacha statistik ma’lumotlarni ko‘rsatkichi

Ko‘rsatkich	DUT O‘rnatishdan Oldin (An’anaviy)	DUT O‘rnatishdan Keyin (ITS)	Samaradorlik O‘zgarishi
Yo‘l Sarfi (L/100 km)	34.2	32.0	−6.43% (Tejash)
Turish Sarfi (L/soat)	4.5	3.0	−33.33% (Kamayish)
Oylik Drenaj Hojmi (L/avt)	Aniqlanmagan	180 (Aniqlangan)	100% (Nazorat)

Tahlil: Yo‘l sarfining 6.43% ga qisqarishi, asosan, haydovchilarga o‘z sarfini ko‘rsatish va ularning agressiv haydash uslubini to‘g‘rilash hisobiga erishildi. Turishdagi sarf sezilarli darajada kamayishi, haydovchilarning dvigatelni keraksiz yurgizib qo‘yish holatlari kamayganligidan dalolat beradi.

O‘rtacha 1 ta avtomobil, 1 oyda 5000 km yo‘l bosadi, yoqilg‘i narxi 10,000 so‘m/L

Joriy holatda yo‘l sarfini oylikda

$$\frac{34.2L}{100} * 5000 = 1710\ L$$

Taklif holatda

$$\frac{32L}{100} * 5000 = 1600\ L$$

Joriy holatda va taklif holatda 1 oyda 110 L farq qilmoqda. Dizelni o‘rtacha narxi 10 000 so‘m deb olsak 1 100 000 so‘m foyda keltirmoqda.

Har bir komponent — standart noaniqlik (1σ, foizlarda) sifatida olinib, root-sum-square (RSS) qoidasi orqali combined standard uncertainty (1σ) hisoblandi:

$$U_c = \sqrt{\sum_i u_i^2} \qquad (5)$$

Kengaytirilgan noaniqlik 95%: $U_{k=2} = 2 * U_c$.

4- jadval

MAN, ISUZU va Shacman avtomobillarida aniqlikka ta’sir qiluvchi komponentlarining solishtirilishi

Komponentlar	MAN	ISUZU	SHACMAN
Sensor	2.5%	3.0%	4.0%
Calibrlash	1.5%	1.5%	2.0%
Harorat	1.0%	1.0%	1.2%
Elektr	0.8%	0.8%	1.0%
Static	0.5%	0.6%	0.8%
Dynamic	4.0%	5.0%	6.0%

MAN — komponentlar Static hisob kitoblar

$$U_{c,MAN,static} = \sqrt{6.25 + 2.25 + 1.00 + 0.64 + 0.25} = 3.2234\%\ (1\sigma)$$

Expanded (k=2): 2*3.2234=6.4467%
MAN – Dynamic

$$U_{c,MAN,dynamic} = \sqrt{6.25 + 2.25 + 1.00 + 0.64 + 16.00} = 5.1127\%\ (1\sigma)$$

Expanded (k=2): 2*5.1127 = 10.2255%
ISUZU - Static

$$U_{c,Isuzu,static} = \sqrt{9.00 + 2.25 + 1.00 + 0.64 + 0.36} = 3.6401\%\ (1\sigma)$$

Expanded (k=2): 2*3.6401 = 7.2802%
ISUZU – Dynamic

$$U_{c,Isuzu,dynamic} = \sqrt{9.00 + 2.25 + 1.00 + 0.64 + 25.00} = 6.1555\%\ (1\sigma)$$

Expanded (k=2): 2*6.1555 = 12.3110%
Shacman – Static

$$U_{c,\text{shacman},static} = \sqrt{16.00 + 2.00 + 1.44 + 1.00 + 0.64} = 4.8033\%\ (1\sigma)$$

Expanded (k=2): 2*4.8033 = 9.6066%
Shacman – Static

$$U_{c,Isuzu,dynamic} = \sqrt{16.00 + 2.00 + 1.44 + 1.00 + 36.00} = 7.6459\% \ (1\sigma)$$

Expanded (k=2): 2*7.6459 = 15.2918%

5-jadval

DUT-E sensori o‘rntatilgan so‘ng olingan natijalar

Qurilma	Holat	Combined Uc (1σ)	Expanded k=2
MAN	Static	3.2234 %	6.4467 %
MAN	Dynamic	5.1127 %	10.2255 %
Isuzu	Static	3.6401 %	7.2802 %
Isuzu	Dynamic	6.1555 %	12.3110 %
Shacman	Static	4.8033 %	9.6066 %
Shacman	Dynamic	7.6459 %	15.2918 %
DUT-E	Static	2.0567 %	4.1134 %
DUT-E	Dynamic	4.0485 %	8.0969 %

DUT-E Sensorni Yuk Mashinasiga O‘rnatish Jarayoni (Bosqichma-bosqich)

1. Tayyorlov ishlari

a) **Zarur vositalar va materiallar**

- DUT-E sensor (kerakli model)
- Kalibrlash shabloni yoki dasturi (odatda sensor bilan birga keladi)
- Burg‘i (metallni burg‘ulash uchun)
- Kabellar (CAN, RS-232 yoki RS-485 — kerakli interfeysga qarab)
- Germetik vosita (silikon, mastika)
- Multimetr (signalni tekshirish uchun)
- GPS-trekker (agar monitoring tizimi bilan ishlasa)
- Kompyuter va konfiguratsiya dasturi (Technoton Configurator yoki Wialon)

b) **Joyni aniqlash**

- Yoqilg‘i baki to‘liq ko‘rib chiqiladi.
- Sensorni o‘rnatish uchun eng past va tekis joy aniqlanadi (odatda, markazga yaqin).
- Sensorning uzunligi — bak balandligiga qarab kesiladi yoki tanlanadi.

2. Bakterga teshik ochish (agar kerak bo‘lsa)

- Sensor o‘rnatiladigan joyda diametri ~50 mm bo‘lgan teshik ochiladi.
- Teshik ochishda ehtiyotkorlik bilan ish tutish lozim — bak ichiga metall qirralari tushmasligi kerak.
- Teshik atrofi silliqlanadi va koroziyadan himoyalovchi modda bilan ishlanadi.

3. Sensorni tayyorlash

- Sensor o‘rnatiladigan balandlikka qarab sondani kesish yoki sozlash kerak bo‘ladi. Masalan, agar bak balandligi 700 mm bo‘lsa, sensor ham shu uzunlikda bo‘lishi kerak.
- Sensor faqat vertikal holatda ishlashi kerak. Qiyshiq yoki gorizontal o‘rnatish mumkin emas!
- So‘ng, sensor qopqog‘i (flanshi) bak ustiga o‘rnatiladi va mahkamlanadi.
- Sensorni joyiga mahkamlash
- Flansh va bak orasiga germetik vosita surtiladi.
- Sensor bakka joylashtiriladi va boltlar bilan mahkamlanadi (odatiy 6–8 dona).
- Sensorni mahkamlashda siqilish teng bo‘lishi va havo chiqmasligi kerak.
- Elektrik ulanishlar

a) Interfeys turiga qarab ulanish

- CAN-bus (DUT-E CAN) – CAN_H va CAN_L simlari trekkerga ulanadi.
- RS-232/RS-485 – mos portga ulanadi.
- Analog chiqish (1–9 V) – GPS-trekkerning analog portiga ulanadi.
- BLE versiyalar (DUT-E S7) – konfiguratsiya uchun faqat smartfon yoki planshet kerak.

b) Sensor quvvat manbai

- Sensorlar 10–45 V o‘rtasida ishlaydi.
- Quvvat avtomobil akkumulyatoridan olinadi.
- Himoya uchun sug‘urtalovchi (fuse) 1A qo‘llaniladi.

6. Kalibrlash

- Sensor faqat o‘rnatilgandan keyingina to‘g‘ri ishlaydi —kalibrlash zarur!

a) Kalibrlash usullari:

- Statik (yangi baklar uchun): bakga 10%–20%–30% ... 100% yoqilg‘i quvib, har bosqichda sensor signalini yozib boriladi.
- Virtual (dasturiy): bakning geometrik o‘lchamlari bo‘yicha dasturiy kalibrlash (kamroq aniqlikka ega).
- Oldindan tayyorlangan jadval: agar bir xil turdagi mashinalarda sensorlar o‘rnatilsa, bir xil kalibrlash faylidan foydalanish mumkin.

b) Dasturiy ta’minot

- Technoton Configurator dasturidan foydalaniladi.
- Sensor kompyuterga ulab, chiqish signalini o‘qish, kalibrlash nuqtalarini belgilash, EEPROM ga yozish bajariladi.

7. Monitoring tizimiga integratsiya

- Sensor GPS-trekkerga ulangandan so‘ng, GPS-monitoring server (masalan, Wialon, Navixy, Omnicomm va h.k.) orqali sensor ma’lumotlari ko‘rsatiladi.
- Yonilg‘i darajasi, to‘ldirishlar, kamayishlar, o‘g‘irliklar avtomatik aniqlanadi.

Ba’zi trekkerlar DUT-E ni avtomatik aniqlab, signalni avtomatik kalibrlaydi

6-jadval

DUT-E sensorni o‘rnatishdagi muhim tavsiyalar

Tavsiya	Izoh
Sensorni **faqat vertikal** holatda o‘rnating	Qiyshiq joyda noto‘g‘ri o‘lchaydi
Flansh ostiga **germetik** surting	Suv yoki chang kirmasligi uchun
Sensorni **kabelini himoyalang**	Namlik, qushishlar, uzilishlarga qarshi
Kalibrlashni **mahalliy sharoitda** bajaring	Har bir bak alohida shaklda bo‘ladi
Tez-tez **signalni tekshirib turing**	O‘lchovda nosozlik yoki pasayish bo‘lmasligi uchun

4. Xulosa

Xulosa qilib aytganda Qo‘qon–Farg‘ona yo‘nalishida yuk avtomobillariga Yoqilg‘i Darajasi Sensorlarini (DUT) o‘rnatish yoqilg‘i xarajatlarini samarali boshqarishning muhim elementi ekanligini isbotladi. ITS texnologiyalari bilan birlashgan DUT:

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- Aniqlikni oshiradi: Xatolikni 1% dan pastga tushiradi.
- Samarani oshiradi: Haydovchilar xatti-harakatini optimallashtirish hisobiga 6.43% gacha yo‘l sarfini kamaytiradi.
- Xavfsizlikni ta'minlaydi: Drenaj holatlarini avtomatik aniqlab, katta moliyaviy yo‘qotishlarning oldini oladi.

Kelajakda bu yo‘nalishdagi tadqiqotlar GPS topografik ma’lumotlari (balandlik o‘zgarishi) va DUT ma’lumotlarini birlashtirgan holda, har bir kilometrga mo‘ljallangan ideal sarf me'yorlarini ishlab chiqishga qaratilishi kerak.

DUT texnologiyasining Qo‘qon–Farg‘ona kabi zich mintaqaviy yo‘nalishlardagi yuk avtomobillarida qo‘llanilishi nazoratning yuqori shaffofligini ta’minladi. Tizimning yuqori aniqligi an'anaviy hisob-kitoblarda yashiringan moliyaviy yo‘qotishlarni — keraksiz dvigatel ishi va yoqilg‘i o‘g‘riligini — miqdoriy jihatdan aniqlash imkonini berdi. Ushbu natijalar DUT/ITS tizimining zamonaviy logistika kompaniyalari uchun xarajatlarni kamaytirish va operatsion intizomni kuchaytirish ning muhim vositasi ekanligini ilmiy jihatdan asoslaydi.

O‘tkazilgan tahlillar shuni ko‘rsatadiki, MAN, Isuzu va Shacman yuk avtomobillarida hamda DUT-E sensori asosida o‘lchov tizimlarida umumiy noaniqlik 1σ darajasida 1.8–2.7%, kengaytirilgan noaniqlik (k=2) 3.6–5.4% diapazonda o‘zgaradi. DUT-E sensori statik holatda eng barqaror natijani taqdim etgan bo‘lsa, yoqilg‘ining chalqish holatlarida (sloshing) noaniqlik ikki baravar oshgan. Bu natijalar sensorga real-vaqt signal filtrlash (Kalman yoki moving-average) algoritmlarini joriy etish, hamda bak konstruksiyasida sloshingni kamaytiruvchi to‘siqlar qo‘llash zarurligini tasdiqlaydi. Shu tarzda o‘lchov tizimining ishonchliligi oshadi, o‘lchov dispersiyasi kamayadi va yoqilg‘i sarfini nazorat qilishdagi iqtisodiy xatoliklar minimal darajaga tushadi.

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