

# EFFECTIVE APPROACH TO ANALYTICAL, ANGLE RESOLVED SIMULATION OF PISTON–CYLINDER FRICTION IN IC ENGINES

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**ABSTRACT:** Most frequently used approach to describe, model and analyse engine effective performance and mechanical losses is largely based on global, time/angle averaged empirical friction models. Importance of detailed, systematic approach to simulation of motor car and its real-world behaviour in terms of combustion efficiency and overall fuel consumption is greater than ever. Therefore, commonly employed empirical or semi-empirical approaches seem insufficient in terms of precision and capabilities for global optimisation of power train system which poses a need to invest more attention into comprehensive angle-resolved, analytical models. Such models have been already presented elsewhere, mainly based on fundamental friction theory of Stribeck, however, simplifications in both slider mechanism dynamic and combustion simulation influenced insufficient accuracy and reliability. In this paper, detailed Stribeck's theory based analytical approach has been employed to model friction in contact of piston ring assembly to cylinder (PRAC) and piston skirt to cylinder (PSC), as well. Gas pressure trace was measured and used to predict instantaneous indicated and effective torque based on engine 1DoF dynamic model and friction models presented in paper.

**KEY WORDS:** engine, friction model, instantaneous crankshaft speed

## EFEKTIVAN PRISTUP ANALITIČKIM, SIMULACIJA REŠENOG UGLA KLIPNOG TRENJA U IC MOTORIMA

**REZIME:** Najčešće korišćen pristup za opisivanje, model i analizu performansi efikasnosti motora i mehaničke gubitke je uglavnom zasnovan na globalnom, vremenskom uglu prosečnog empirijskog modela trenja. Značaj detaljnog, sistematskog pristupa simulaciji motora automobila i njegovog ponašanja u stvarnom svetu u smislu efikasnosti sagorevanja i ukupnoj potrošnji goriva, veći je nego ikada. Stoga se, obično korišćeni empirijski ili polu-empirijski pristupi čine nedovoljnim u smislu preciznosti i mogućnosti za globalnom optimizacijom pogonskog sistema koji ima potrebu ulaganja sa više pažnje u sveobuhvatne strane rešenih analitičkih modela. Takvi modeli su već prezentovani na drugim mestima, uglavnom zasnovani na osnovnoj Stribekovoj teoriji trenja, međutim, pojednostavljenja u oba klizna mehanizma dinamike i simulacije sagorevanja su uticala na nedovoljnu tačnost i pouzdanost. U ovom radu, detaljna Stribekova teorija zasnovana na analitičkom pristupu je uposlena da modelira trenje u kontaktu sklopa klipa prstenova i cilindra (PRAC) i klipnjače i cilindra (PSC) takođe. Trag pritiska gasa je izmeren i korišćen za predviđanje trenutno naznačenog i efikasnog obrtnog momenta na osnovu motora jednog stepena slobode dinamičkog modela i trenja modela prikazanog u radu.

**KLJUČNE REČI:** motor, trenje modela, trenutna brzina radilice

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