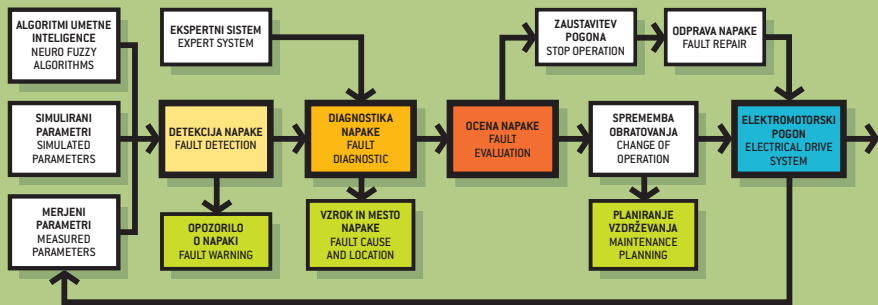




DIAGNOSTIČNI  
SISTEMI ZA  
ASINHRONSKE  
MOTORJE  
DIAGNOSTIC  
SYSTEMS FOR  
INDUCTION  
MOTORS



Trifazni asinhronski motorji so najštevilčnejši električni pogonski stroji v industriji. Kljub robustni konstrukciji motorja prihaja do napak med obratovanjem, ki jih zaznamo preko sekundarnih učinkov (zmanjšana moč, povečano segrevanje, vibracije in hrup, nezanesljiv zagon, podrsavanje rotorja ob stator] šele v fazi, ko je poškodba že povzročila večjo motnjo v industrijskem procesu.

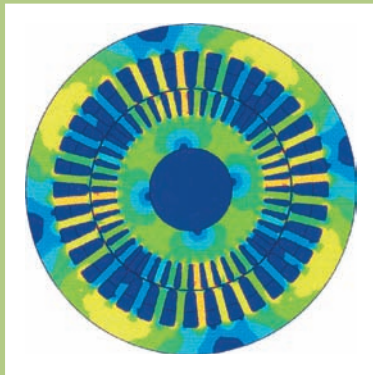
V primeru, ko pogone spremljamo z ustreznimi diagnostičnimi orodji, napako predvidimo vnaprej, motor zamenjamo oziroma izvršimo popravilo v času, ko zaradi tega ne trpi tehnološki proces ali varnost postroja. S pomočjo „on-line“ sistema neprekinjenega nadzora v realnem času zaznamo nastajajoče napake že v začetni fazi, ko še ne predstavljajo neposredne nevarnosti za okvaro sistema.

Precejšen delež okvar pri asinhronskih motorjih predstavljajo napake v rotorski kratkostični kletki, ki med obratovanjem za meritve ni dostopna, zato informacije o nastajajočih poškodbah pridobivamo s pomočjo sistematičnega merjenja in analize statorskega toka.

Three-phase cage induction motors are the most widely used type of electrical motors in industry. Despite their simple and robust construction, several possible faults can occur during heavy-duty operation. These faults cause serious disturbances (motor performance reduction, overheating, increasing noise and vibration, unreliable starting, rotor to stator rubbing), or even unexpected shutdown of the production process.

In cases where electrical drives are supervised by appropriate diagnostic tools, arising faults could be foreseen and the maintenance procedures are scheduled to the most convenient terms regarding technological process and safety of the drive. The main advantage of the on-line condition monitoring system is the prediction of the unexpected breakdown of the drive by detecting failure states at the early-stage when the drive is still operating normally.

Significant percentage of induction motor faults represent rotor cage asymmetries. Rotor currents can not be measured during the operation of the motor thus information of the cage healthy state is acquired by analysing stator current.



Iz frekvenčnega spektra statorskega toka asinhronskega motorja in poznavanja fizikalnega dogajanja znotraj magnetnega polja lahko razberemo naslednje okvare in poškodbe:

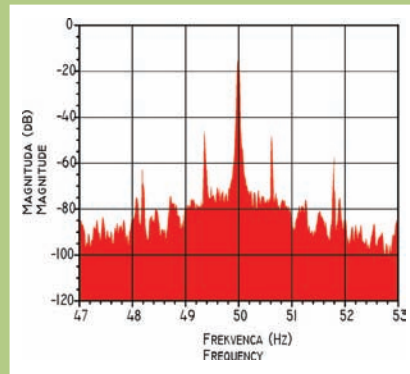
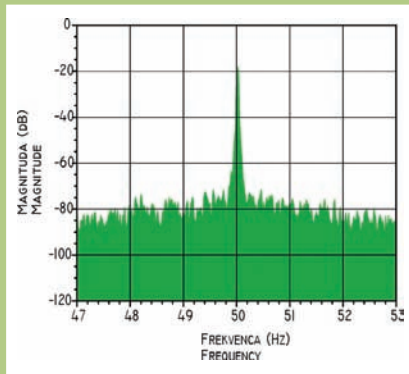
- prekinjene ali zlomljene rotorske palice, prekinjene ali počene segmente kratkostičnega obroča,
- visokoohmske spoje v kratkostični kletki kot posledico poroznosti aluminija,
- pomanjkljive spoje trdo spajkanih bakrenih kletk,
- napake v navitih rotorjih,
- statične in dinamične nepravilnosti v zračni reži,
- neuravnoteženost magnetne sile,
- upognjeno gred, mehanske deformacije zaradi termične obremenitve,
- eliptičnost statorskega in rotorskega paketa,
- izrabljenost ležajev.

Metoda je povsem neinvazivna in ne zahteva nobenih dodatnih posegov v vezavo, kot tudi ne fizičnega kontakta z motorjem. Meritev statorskega toka je izvedena s tokovno sondo v priključni celici, diagnostični rezultati pa so enako zanesljivi pri omrežno in pretvorniško napajanih motorjih.

Induction motor rotor faults cause typical changes in magnetic field distribution which are easily detected by analysing frequency spectrum of the measured stator current. Such faults are:

- cracked or broken rotor bars, cracked or broken ending segments and their connections to the bars,
- high resistance areas of aluminium squirrel cage due to porosity and local overheating,
- inferior quality of connections in cooper squirrel cage,
- inter-turn faults in wound-rotor windings,
- static and dynamic eccentricity of the rotor,
- unbalanced magnetic pull,
- bend shaft, mechanical deformations due to thermal stresses,
- elliptical stator and rotor lamination package,
- bearing faults.

Diagnostic method is performed during normal operation of the drive. It is completely non-invasive and does not require physical accesability to the motor as the current transducers are located in control cabinets of the monitored motors. Diagnostic results are equally reliable in cases of inverter fed induction motors.



Neenaka prevodnost posameznih rotorskih palic in segmentov kratkostičnega obroča povzroči nesimetrijo rotorskih tokov. Spremembe v porazdelitvi magnetnega polja se odražajo v frekvenčnem spektru statorskega toka, ki dobi dodatne komponente, katerih položaj je značilen za vsak tip okvare in predstavljajo njen „prstni odtis“.

Z diagnostičnega stališča najznačilnejša komponenta se pojavi pri frekvenci  $[1 \pm 2s]f_s$  levo in desno od osnovne harmonske komponente. Razmerje relativnih amplitud osnovne in stranskih frekvenčnih komponent predstavlja glavni diagnostični indeks pri vrednotenju stopnje poškodbe rotorske kletke.

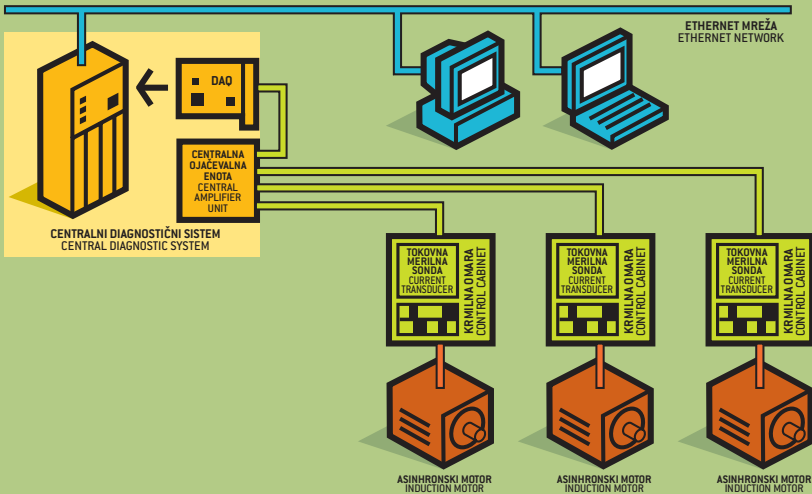
Avtomatizirano periodično merjenje diagnostičnega indeksa omogoča v izbranih časovnih intervalih spremljanje trenda stopnjevanja nesimetrije rotorske kletke in s tem napoved dinamike razvoja okvare ter določitev nujnosti planiranja sanacije okvare. V nasprotnem primeru se poškodba razširi, kar privede do izpada motorja iz obratovanja ali celo uničenja.

Due to some broken bars or end-ring segments asymmetrical rotor currents give rise to local saturations in magnetic field distribution. This causes additional components in the frequency spectrum of the measured stator current which are not present in the case of healthy motor. Each type of fault induces specific components thus representing its typical "signature" which should be identified.

For diagnostic purpose it is most important to detect so called side-band components at frequencies  $[1 \pm 2s]f_s$  near fundamental harmonic. The ratio between magnitudes of side-band and fundamental harmonics represents the effective diagnostic index in estimation procedure of the healthy/faulty state of induction motor rotor cage.

The automated periodical acquisition of the diagnostic index enables continuous tracking of the side-band components variation. Increasing magnitude of the side-band components in a short time period indicates the fault propagation which leads to the risk of a serious damage and such motor needs special precaution in further operation.

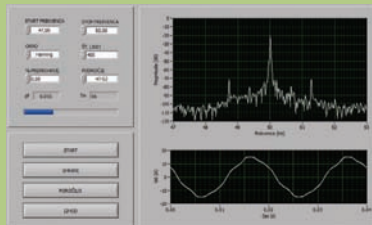
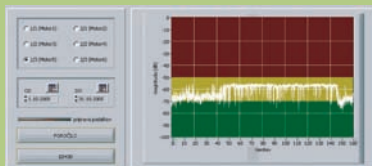
# SHEMA DIAGNOSTIČNEGA SISTEMA DIAGNOSTIC SYSTEM SCHEME



# KOMPONENTE SISTEMA SYSTEM COMPONENTS



# GRAFIČNI VMEŠNIK GRAPHIC USER INTERFACE





ELEK Svetovanje d.o.o.  
LJUBLJANA

Marice Kovačeve 7  
SI-1000 Ljubljana, Slovenia  
phone: +386 (0)1 565 4050  
fax: +386 (0)1 565 4055  
e-mail: info@elek.si  
www.elek.si

v sodelovanju s / collaboration with:



Univerza v Ljubljani  
Fakulteta za električno inženjirstvo  
University of Ljubljana  
Faculty of Electrical Engineering



Laboratorij za elektromotorske pogone  
Laboratory of Electrical Drives

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