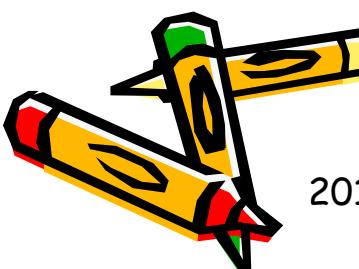
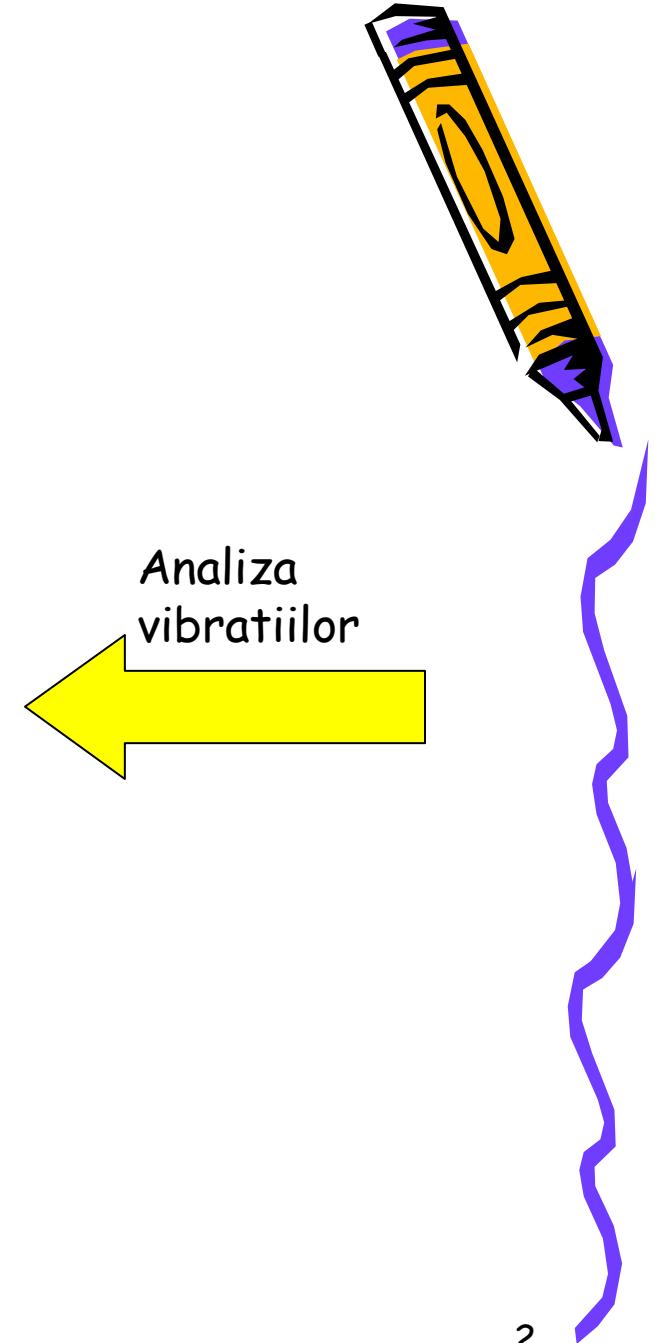
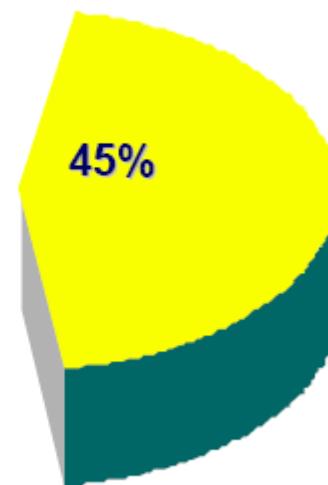
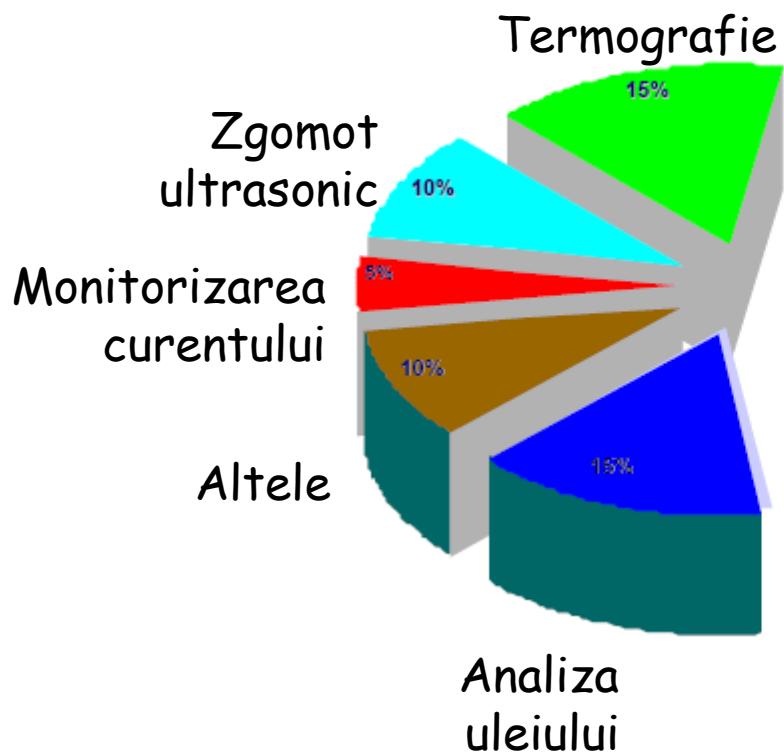


# UTILIZAREA VIBRATIILOR CA SURSA DE DIAGNOSTIC IN SISTEME ROTATIVE

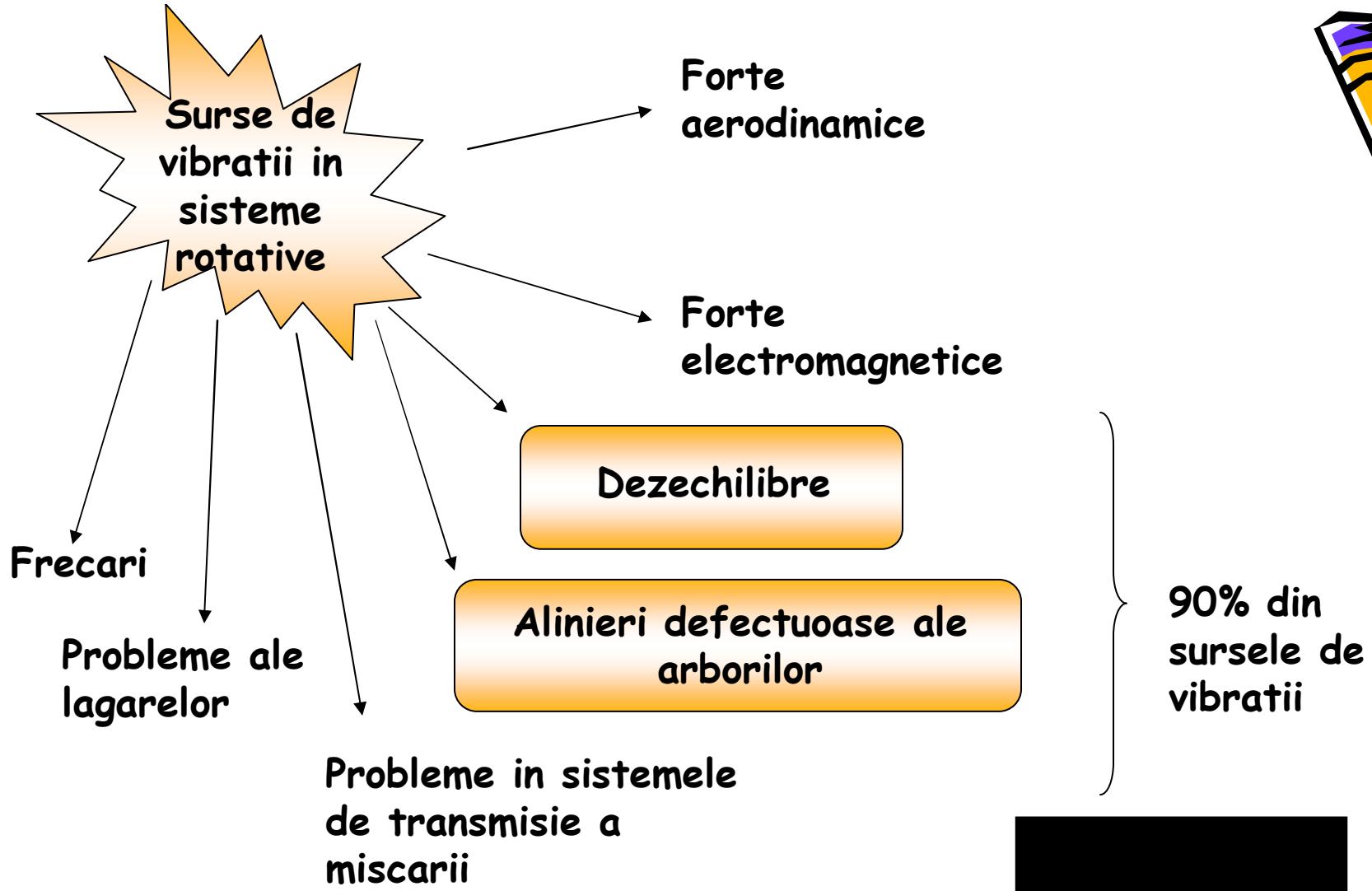
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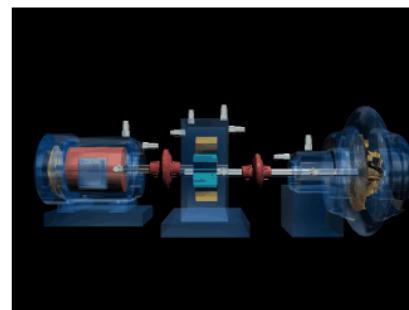


2010-2011

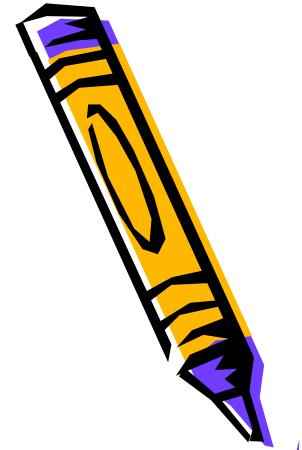


2010-2011

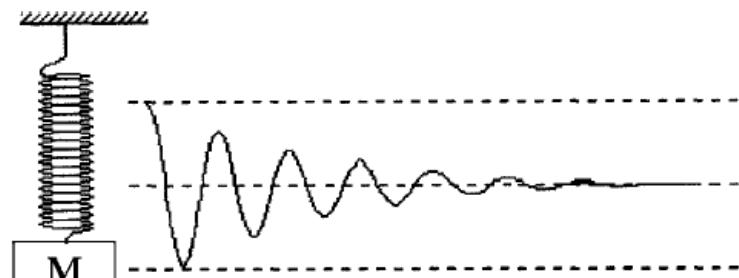
Mantenanta sistemelor industriale - Curs 4



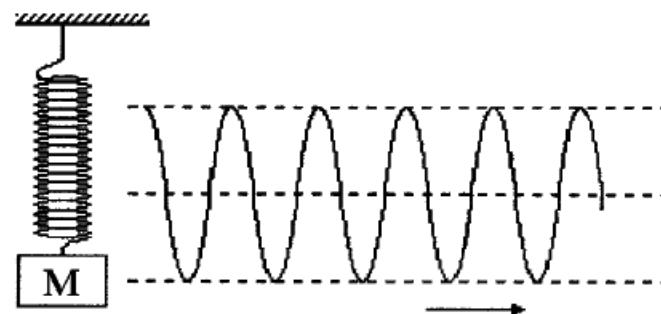
3



## FRECVENTA DE REZONANTA

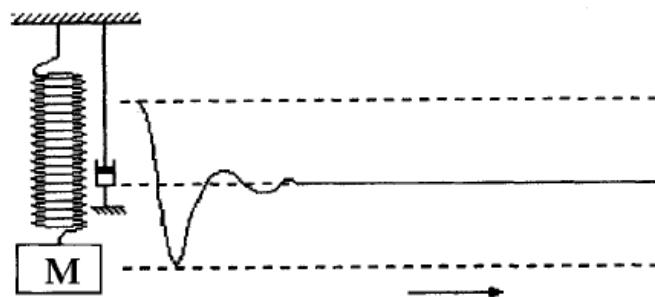


Vibratii libere



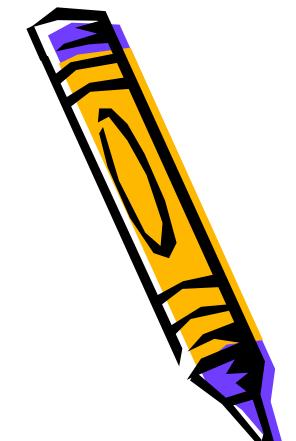
Vibratii intretinute la frecventa proprie

Vibratii amortizate



Pentru a intretine vibratiile la frecventa proprie este necesara o forta exterioara de valoare mai mica, decat pentru alta valoare a frecventei.

Prezenta unei forte exterioare in faza cu oscilatiile proprii va duce la cresterea amplitudinii oscilatiilor.



Factori ce influenteaza  
frecventa proprie de oscilatie:

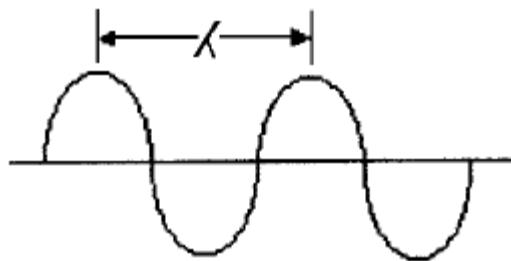
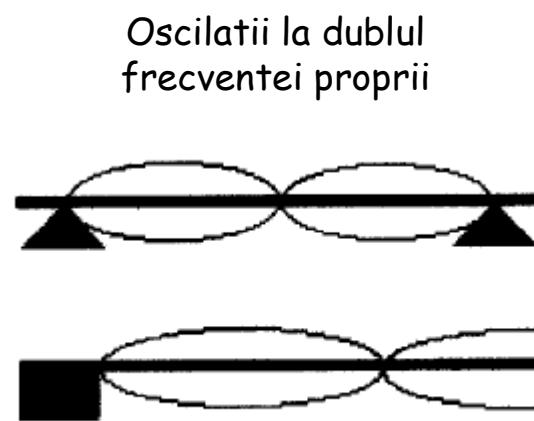
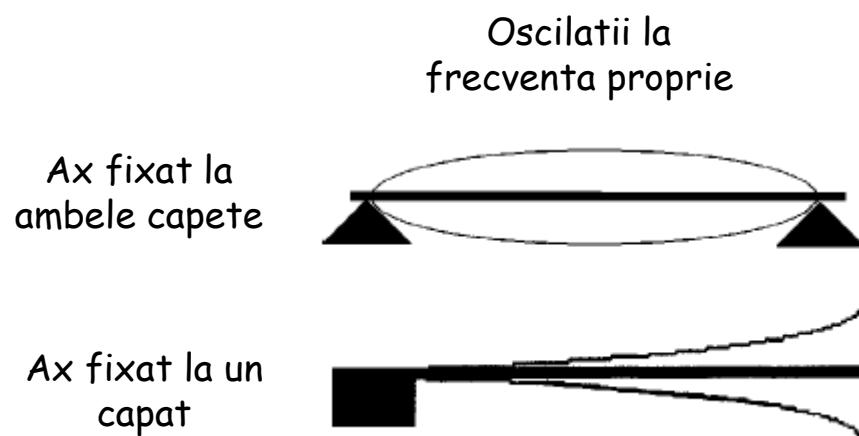
Masa

*Un corp de 9 kg are o  
frecventa proprie de oscilatie  
de 25Hz. Adaugand 2 Kg,  
frecventa proprie de oscilatie  
va scadea la 22.6Hz.*

Rigiditatea

*Un corp de 9 kg are o frecventa  
proprie de oscilatie de 25Hz. Sporind  
rigiditatea acestuia la 440000N/m,  
printr-o legatura metalica  
suplimentara, adaugand astfel 0.5 kg  
frecventa proprie de oscilatie va  
creste la 34.25Hz.*





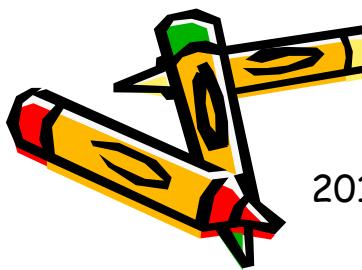
$$\lambda = \frac{2L}{n}$$

Lungimea axului  
Ordinul oscilatiei

Viteza de deplasare a undei

$$v = f\lambda = \sqrt{\frac{E}{\rho}}$$

Modulul de elasticitate  
Densitatea



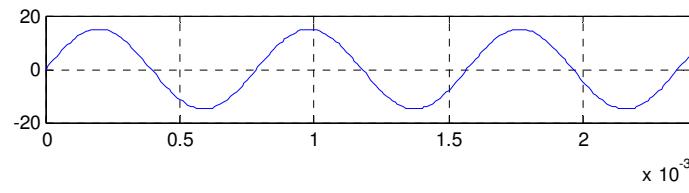
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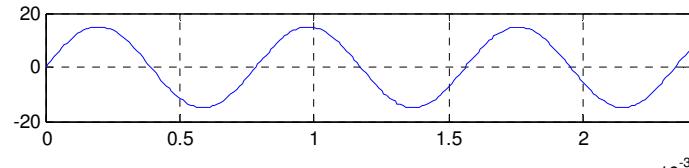
## FRECVENTA DE BATAIE

Frecventa de bataie se datoreaza suprapunerii a doua sau mai multe oscilatii cu frecvente apropiate.

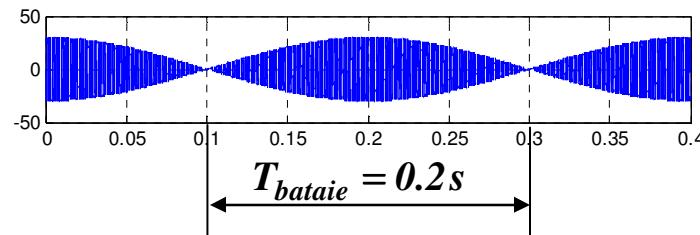
$$X_1 = A \sin(2\pi f_1), f_1 = 1275 \text{ Hz}$$



$$X_2 = A \sin(2\pi f_2), f_2 = 1280 \text{ Hz}$$



$$X_1 + X_2$$

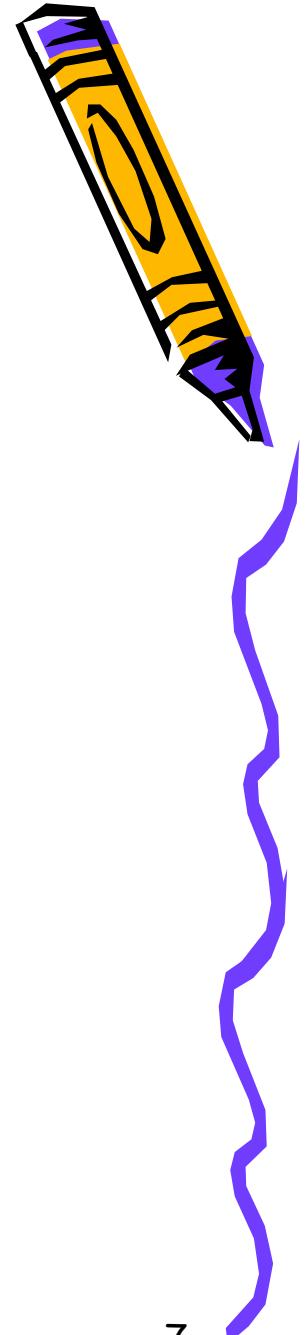


$$f_{bataie} = 5 \text{ Hz}$$

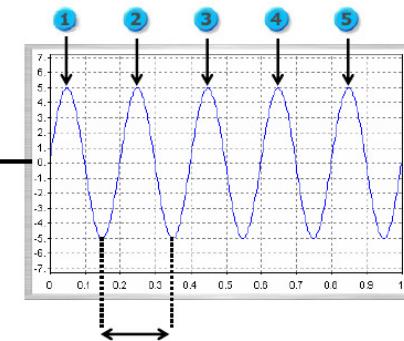
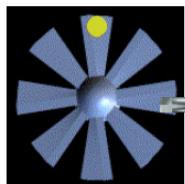


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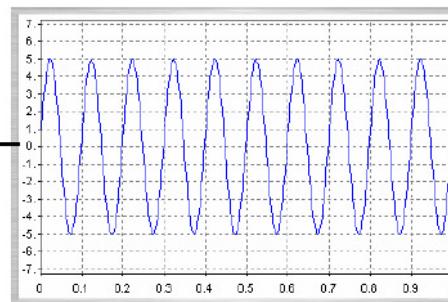
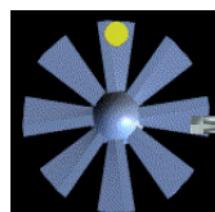
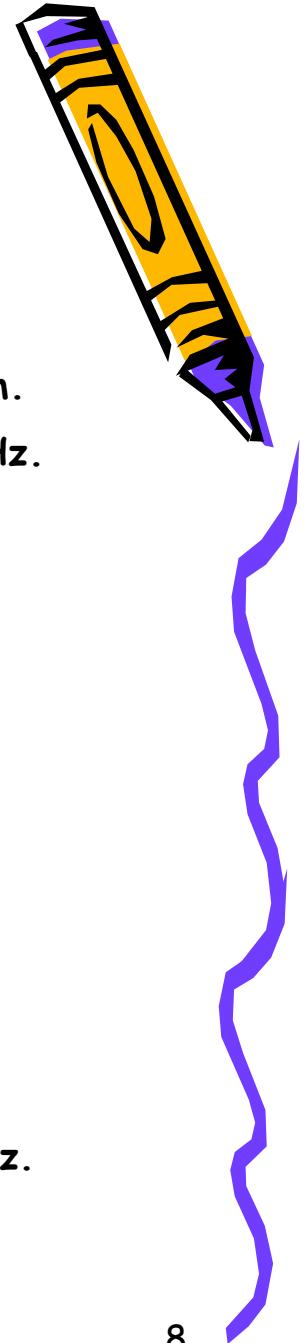


# DEZECHILIBRE

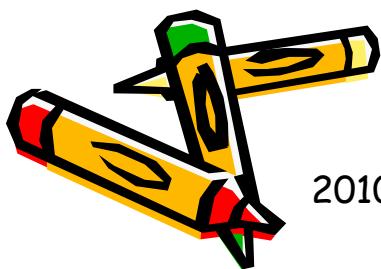


Perioada=1/frecventa

Ventilatorul se roteste cu 300rpm.  
Frecventa vibratiilor este deci 5Hz.



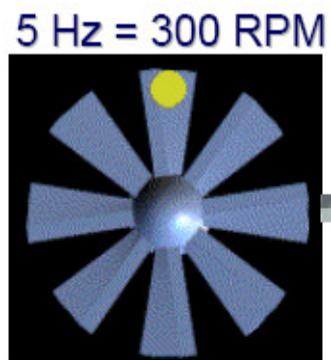
Ventilatorul se roteste cu 600rpm.  
Frecventa vibratiilor este deci 10Hz.



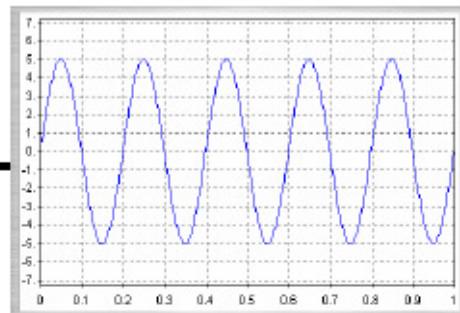
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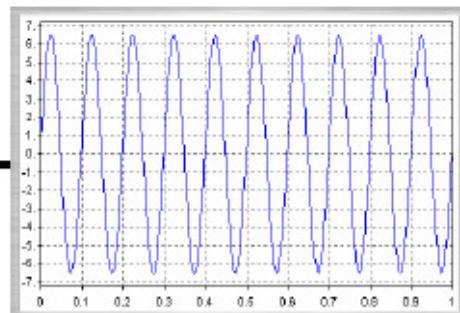
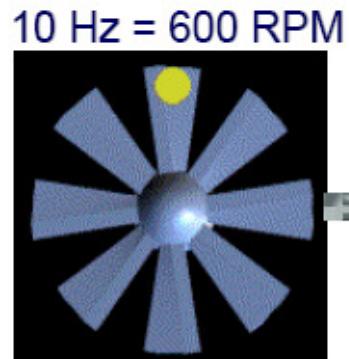
## SPECTRUL VIBRATIILOR



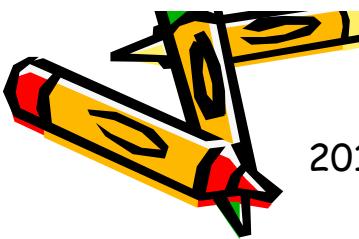
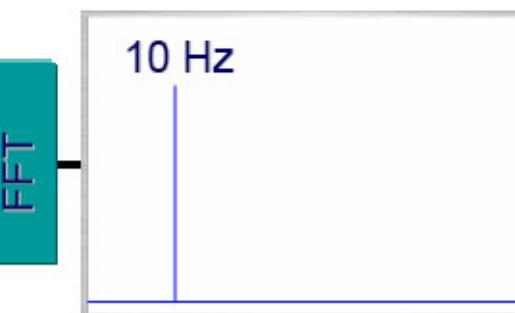
Domeniul timp



Domeniul frecventa

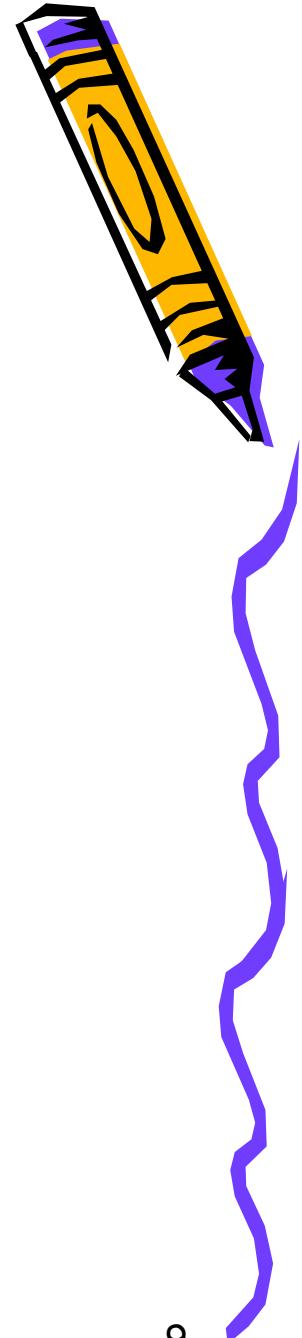


10 Hz

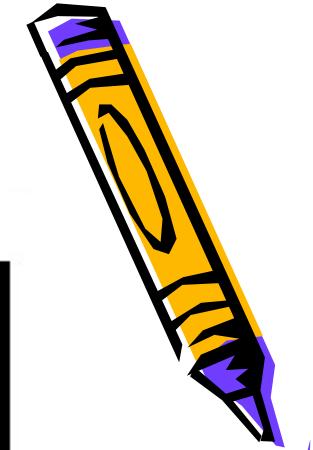
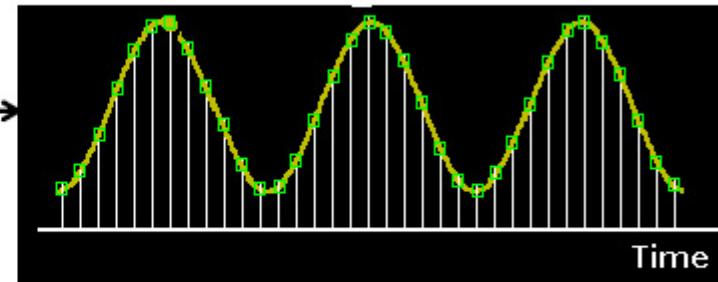
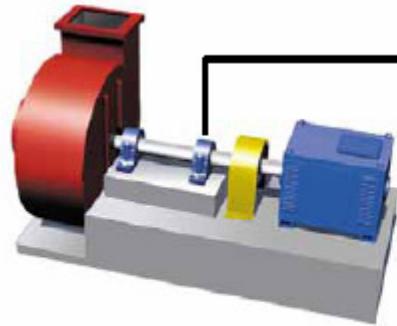


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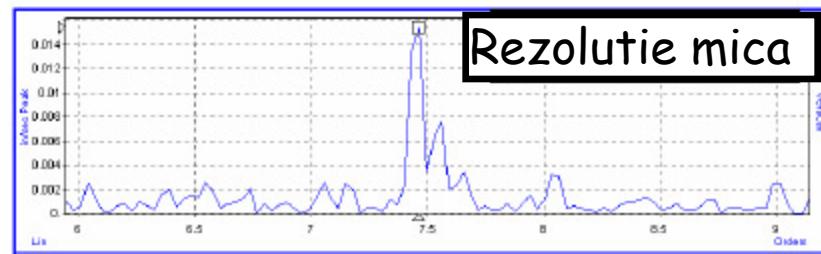
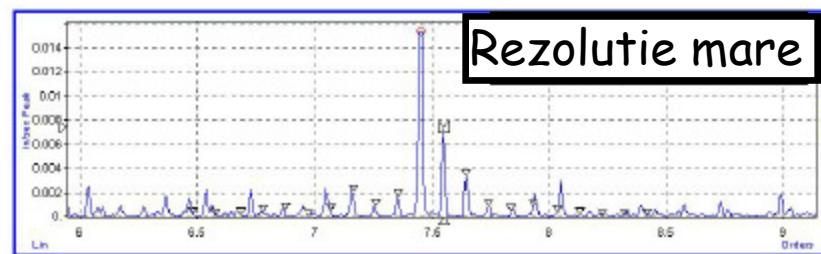
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## REZOLUTIA



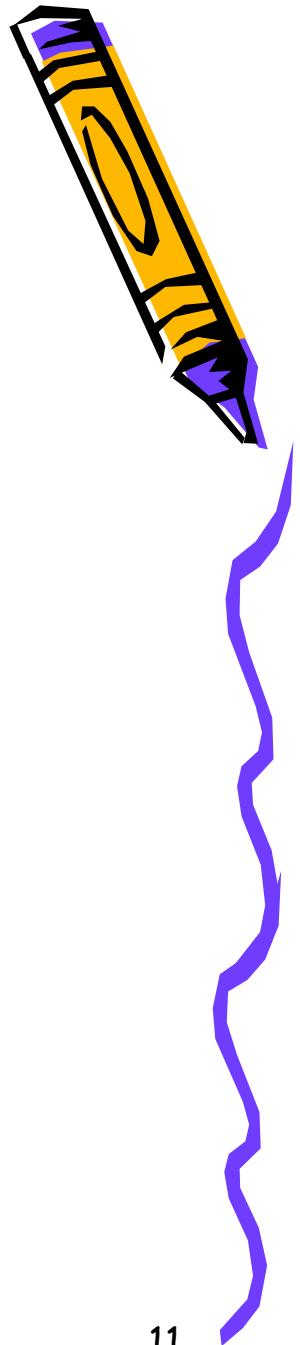
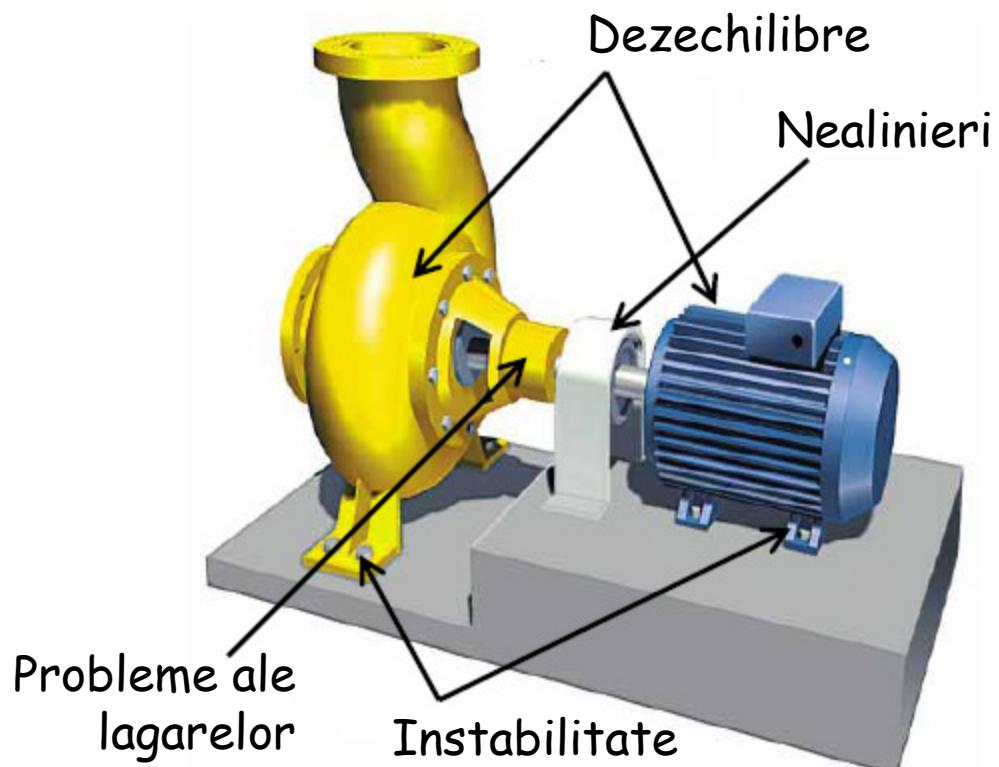
Frecventa de esantionare,  
numarul de esantioane si  
durata achizitiei  
influenteara rezolutia.



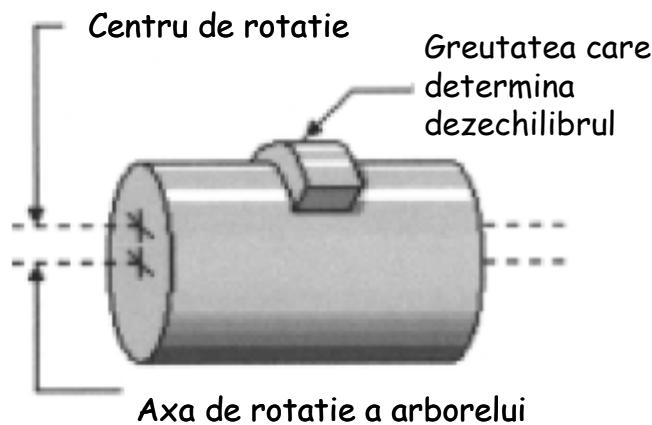
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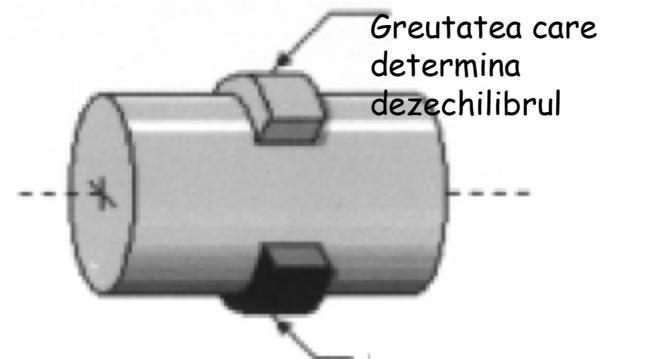
10



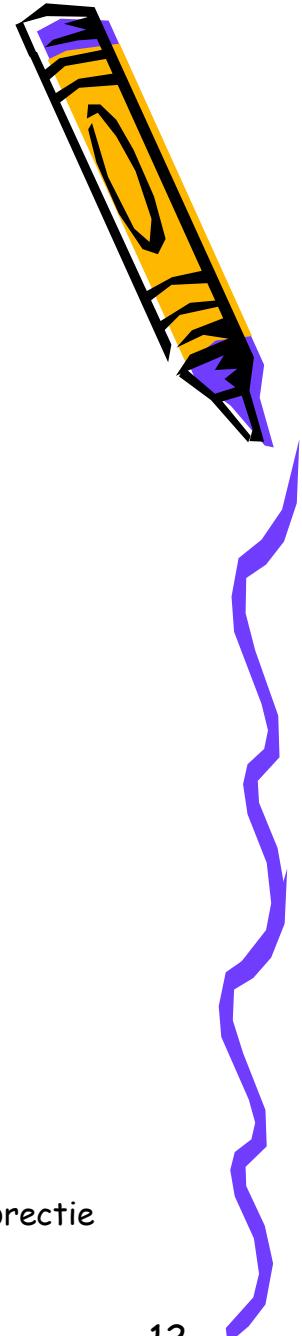
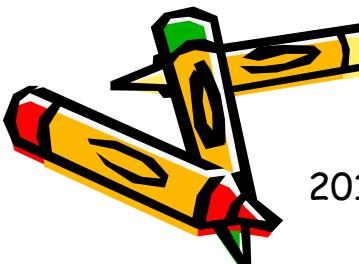
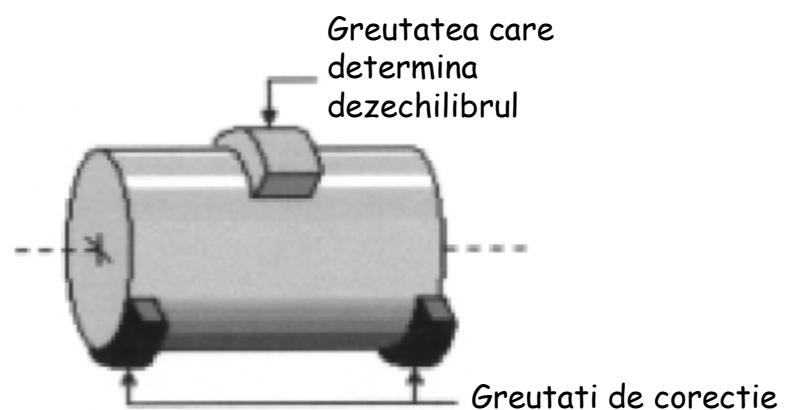
**DEZECHILIBRU STATIC** - axa de rotatie este deplasata paralel cu axa geometrica de rotatie a arborelui



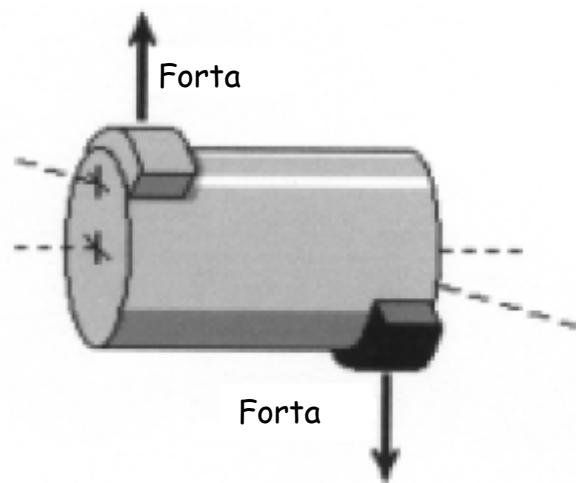
Amplitudinea si faza vibratiilor la cele doua capete sunt aceleasi



Greutate de corectie



**DEZECHILIBRU DE TIP CUPLU** - desi arborele este static echilibrat, elementul tinde sa vibreze in jurul centrului in timpul miscarii de rotatie.



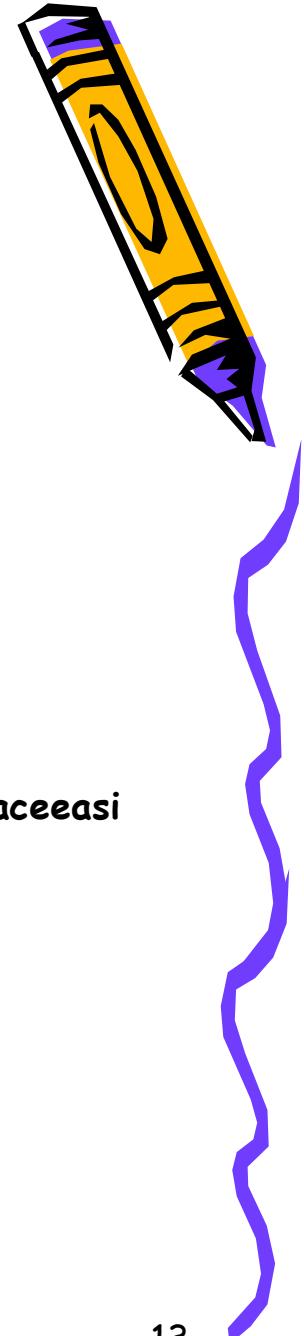
Necesita corectie in mai mult de un plan.  
Ambele capete ale arborelui vor vibra cu aceeasi amplitudine, dar defazate la  $180^\circ$ .



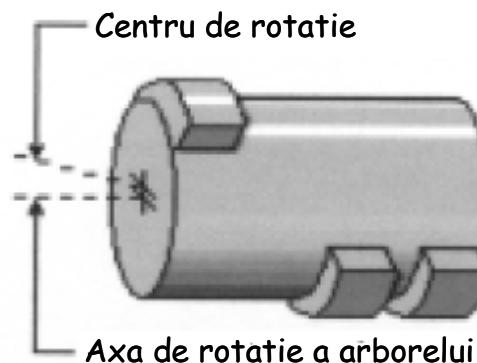
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**DEZCHILIBRU QUASI-STATIC-** varianta de dezechilibru in care centrul de rotatie intersecteaza axa de rotatie a elementului, dar nu in centrul de greutate.



- Necessita corectie in mai mult de un plan.
- Amplitudinile vibratiile la cele doua capete ale arborelui sunt diferite, vibratiile fiind defazate la  $180^\circ$ .



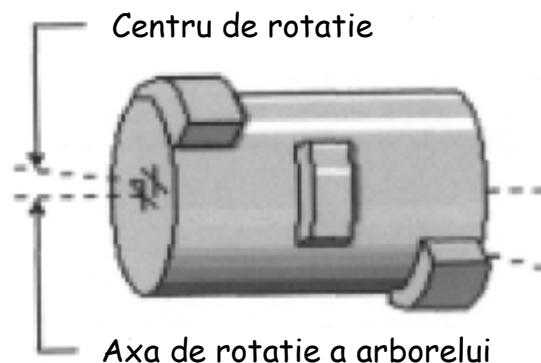
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**DEZECHILIBRU DINAMIC**- varianta de dezechilibru in care centrul de rotatie nu coincide si nici nu intersecteaza axa de rotatie a elementului.



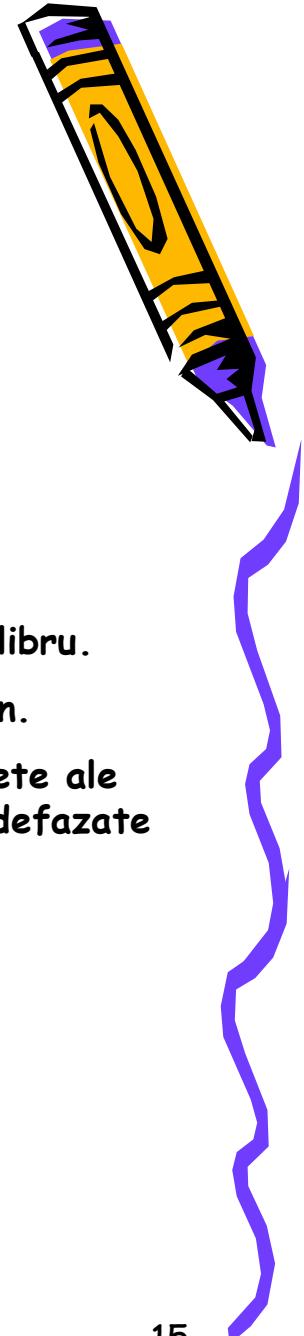
Este cel mai des intalnit tip de dezechilibru.  
Necesa corectie in mai mult de un plan.  
Amplitudinile vibratiilor la cele doua capete ale arborelui sunt diferite, vibratiile fiind defazate la un unghi oarecare.



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**EXEMPLU DE CALCUL.** Un ventilator centrifugal a fost reasamblat dupa o interventie cu o deplasare a centrului de  $d=0.127\mu\text{m}$ , fata de centrul de greutate. Rotorul ventilatorului cantarea m=9 kg si este antrenat la o viteza de 23200rpm. Sa se calculeze forta generata de dezechilibrul creat.

Expresia fortele datorate dezechilibrului este:

$$F = k_{unbalanced} \left( \frac{\Omega}{1000} \right)^2 m * g * d, k_{unbalanced} = 7100$$

cu  $g=10\text{m/s}^2$ , deci, rezulta pentru forta valoarea de:

$$F = 43.7\text{ N}$$

Ceea ce reprezinta 48% din greutatea rotorului.

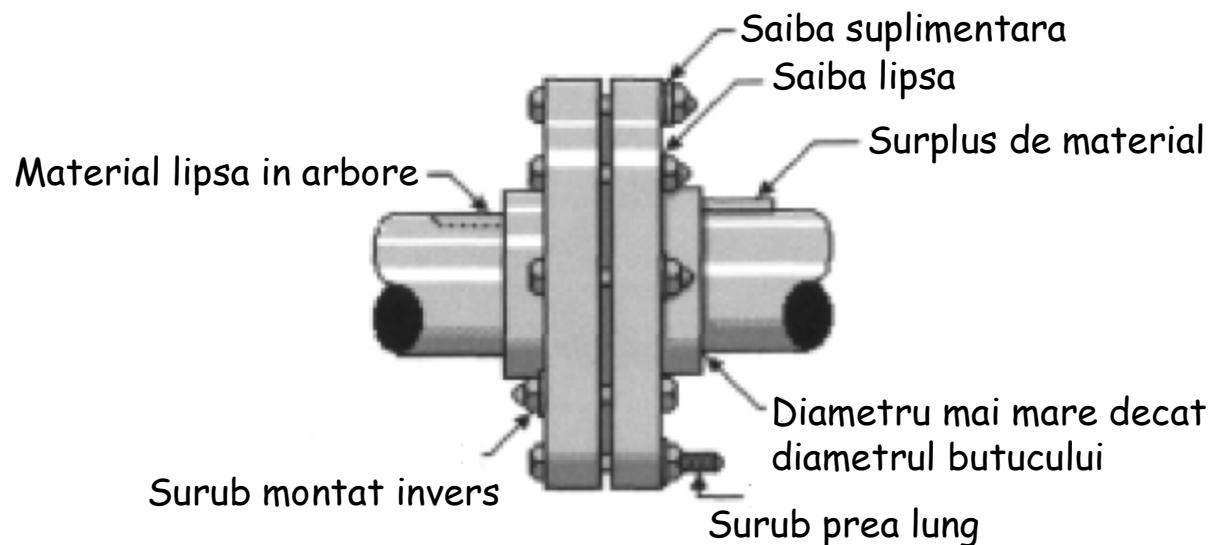


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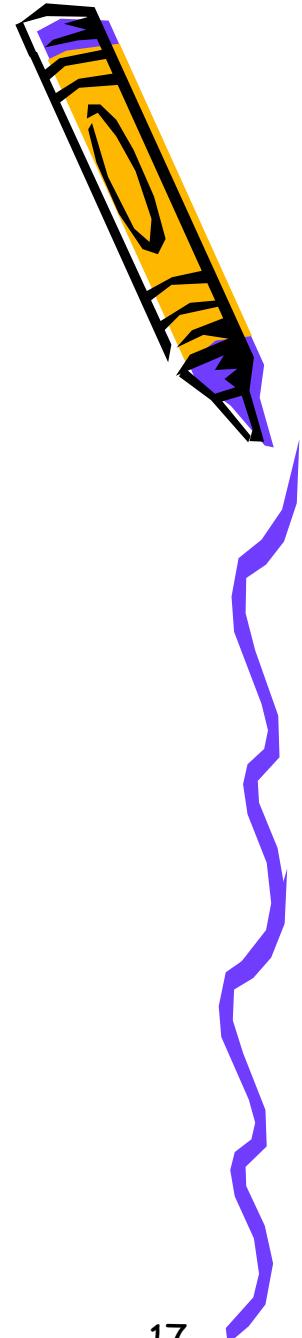
## SURSE DE DEZECHILIBRU LA CUPLAREA A DOI ARBORI



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**EXEMPLU DE CALCUL.** Un volant cu un diametru de 1.8 m si cantarind 863.4 kg, este asamblat pe un arbore cu o eroare  $d=25.4\mu\text{m}$ . Volantul lucreaza la o viteza de rotatie de 300rpm. Sa se calculeze forta generata ca rezultat al dezechilibrului creat.

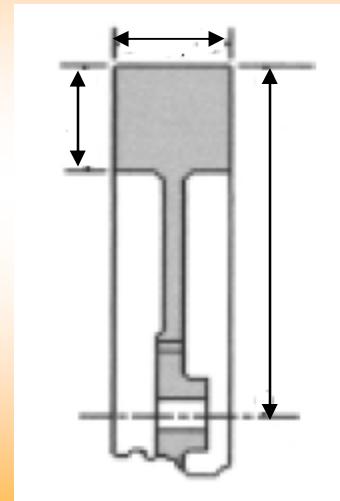
Expresia fortele datorate dezechilibrului este:

$$F = 7100 \left( \frac{\Omega}{1000} \right)^2 m * g * d$$

cu  $g=10\text{m/s}^2$ , deci, rezulta pentru forta valoarea de:

$$F = 621.9\text{N}$$

Ceea ce reprezinta 1.62% din greutatea rotorului.



## CONCLUZII SI OBSERVATII

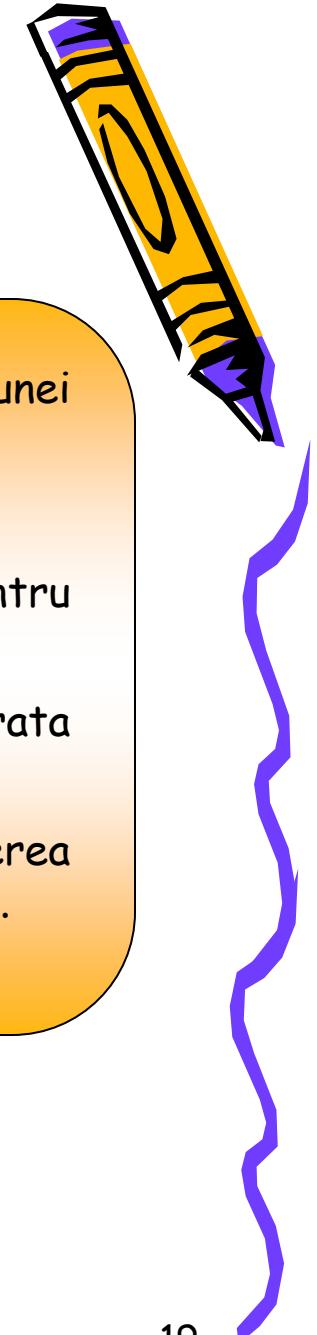
- Frecventa vibratiilor datorate dezechilibrelor este corespunzatoare unei viteze de  $1/v$ , cu  $v$  viteza elementului in rotatie.
- Amplitudinea vibratiilor este proportionala cu marimea dezechilibrului.
- Vibratiile vor fi mai mari pe directie radiala, cu precizarea ca, pentru sisteme cu arbori lungi, exista si componente axiale ale vibratiilor.
- Cu cat viteza de rotatie este mai mare, cu atat forta datorata dezechilibrului este mai mare.
- Pentru motoarele electrice, daca vibratiile dispar odata cu intreruperea alimentarii, atunci acestea se datoreaza componentei electrice a motorului.



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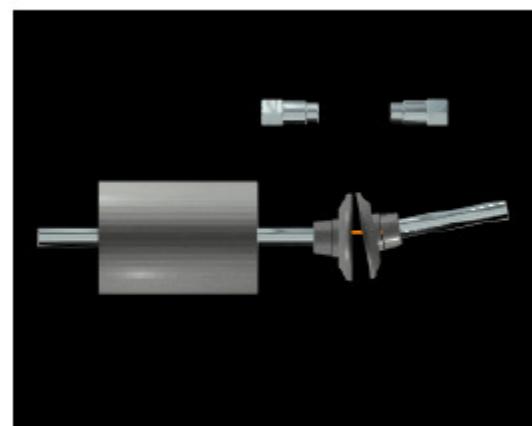
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## ALINIERI DEFECTUOASE

*Interne*- in cazul lagarelor

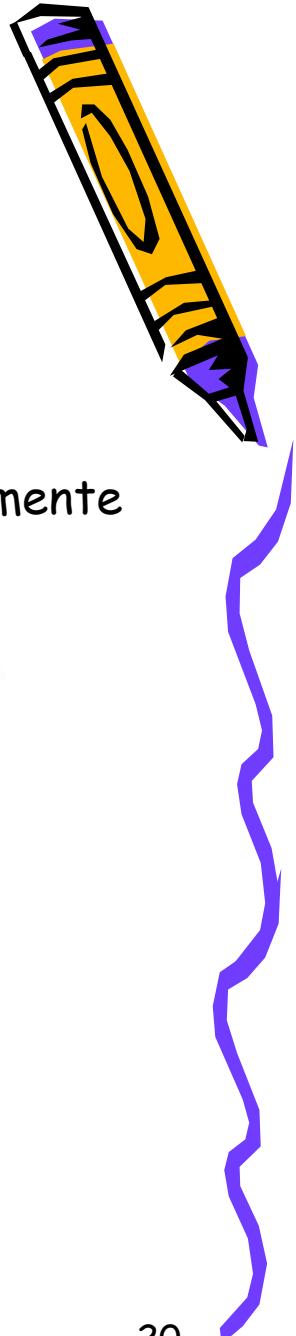
*Externe*- in cazul a doua echipamente care trebuie cuplate impreuna.



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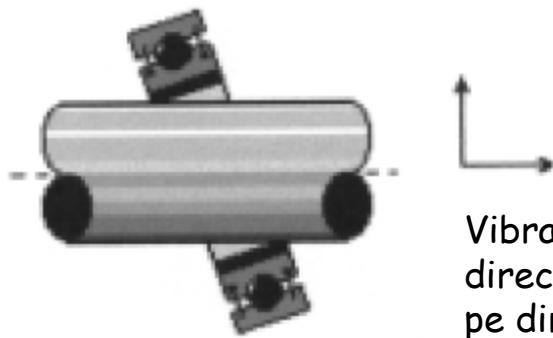


## NEALINIERI INTERNE

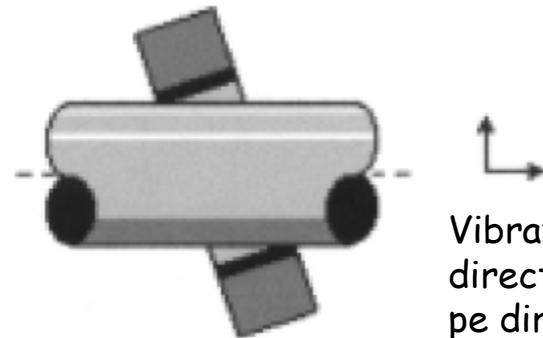
Lagare cu rostogolire



Lagare cu alunecare



Vibratii atat pe  
directie axiala cat si  
pe directie radiala



Vibratii atat pe  
directie axiala cat si  
pe directie radiala

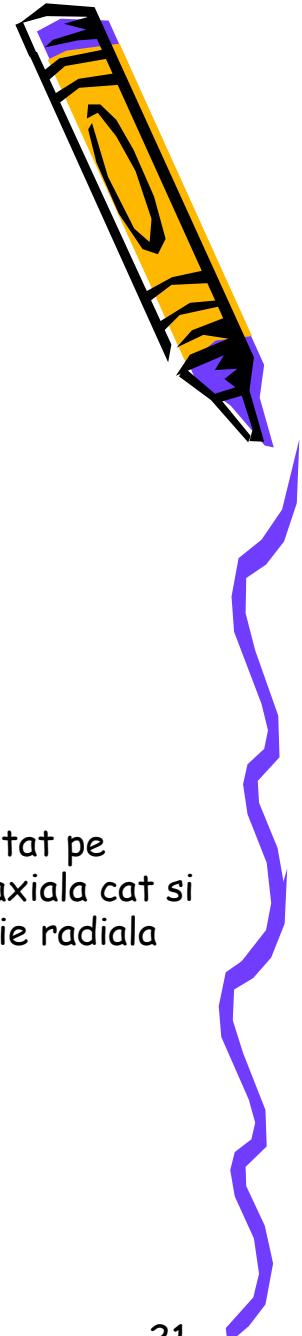


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Sursa nealinierii  
interne este de fapt  
un dezechilibru

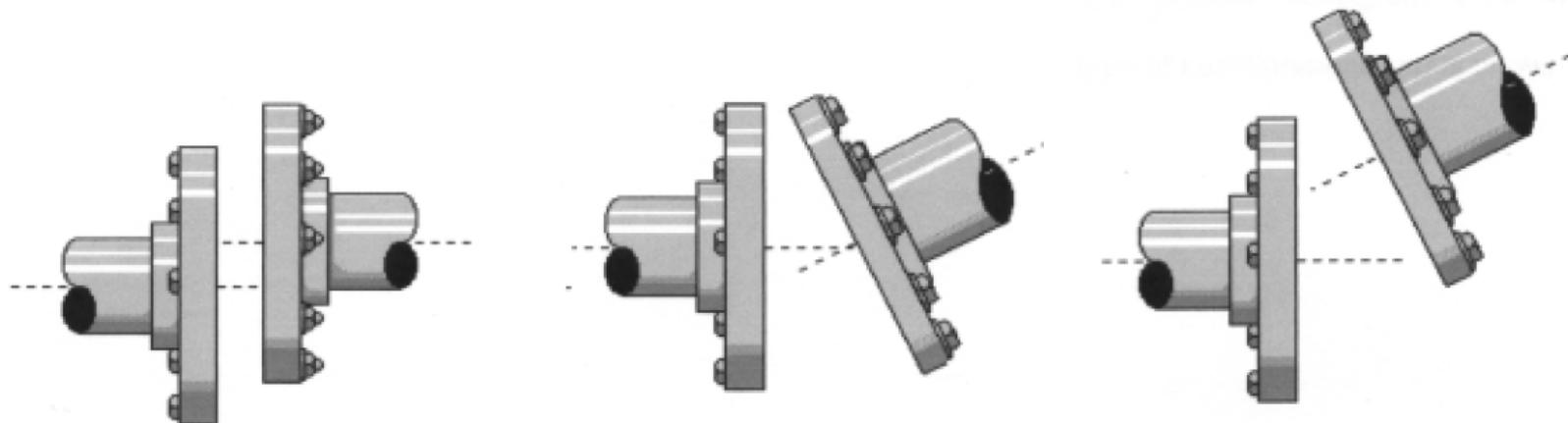
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## NEALINIERI EXTERNE PENTRU CUPLAJE

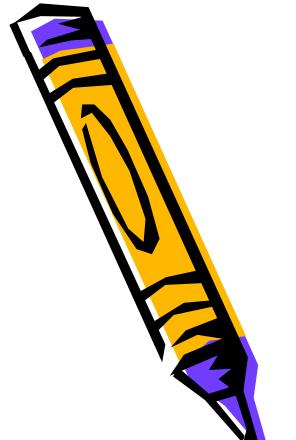
- Datorita nealinierii apar atat forte radiale cat si forte axiale.
- Vibratiile sunt cu atat mai mari cu cat nealinierarea e mai accentuata.
- Frecventa vibratiilor corespunde  $1/v$ , v este viteza de rotatie a arborilor, dar la nealinieri accentuate pot aparea si vibratii la frecvente superioare.



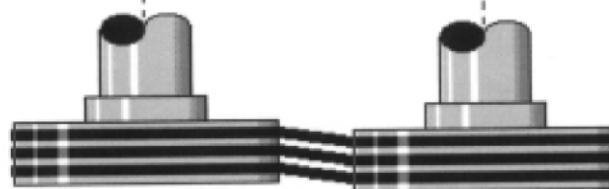
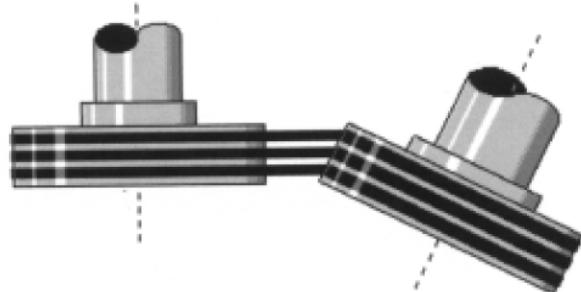
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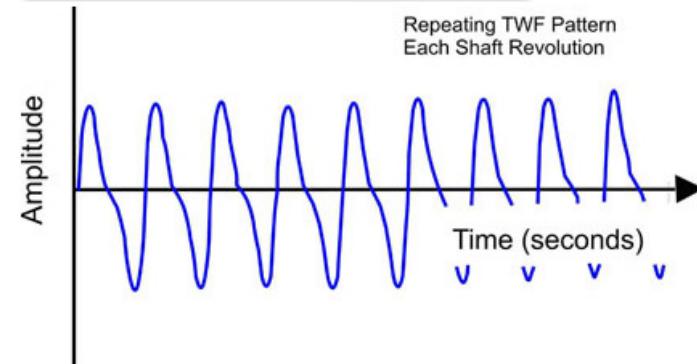
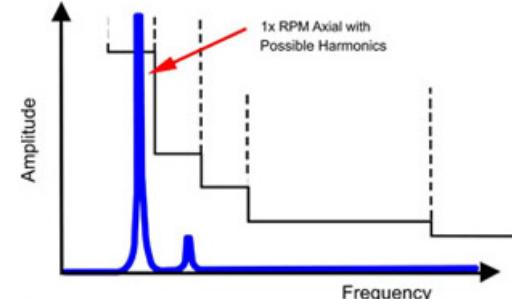
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## NEALINIERI EXTERNE PENTRU CUPLAJE PRIN CURELE

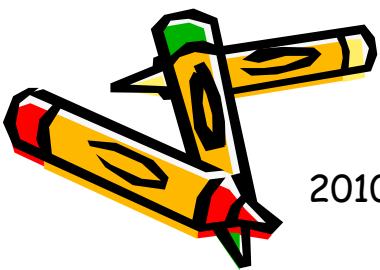
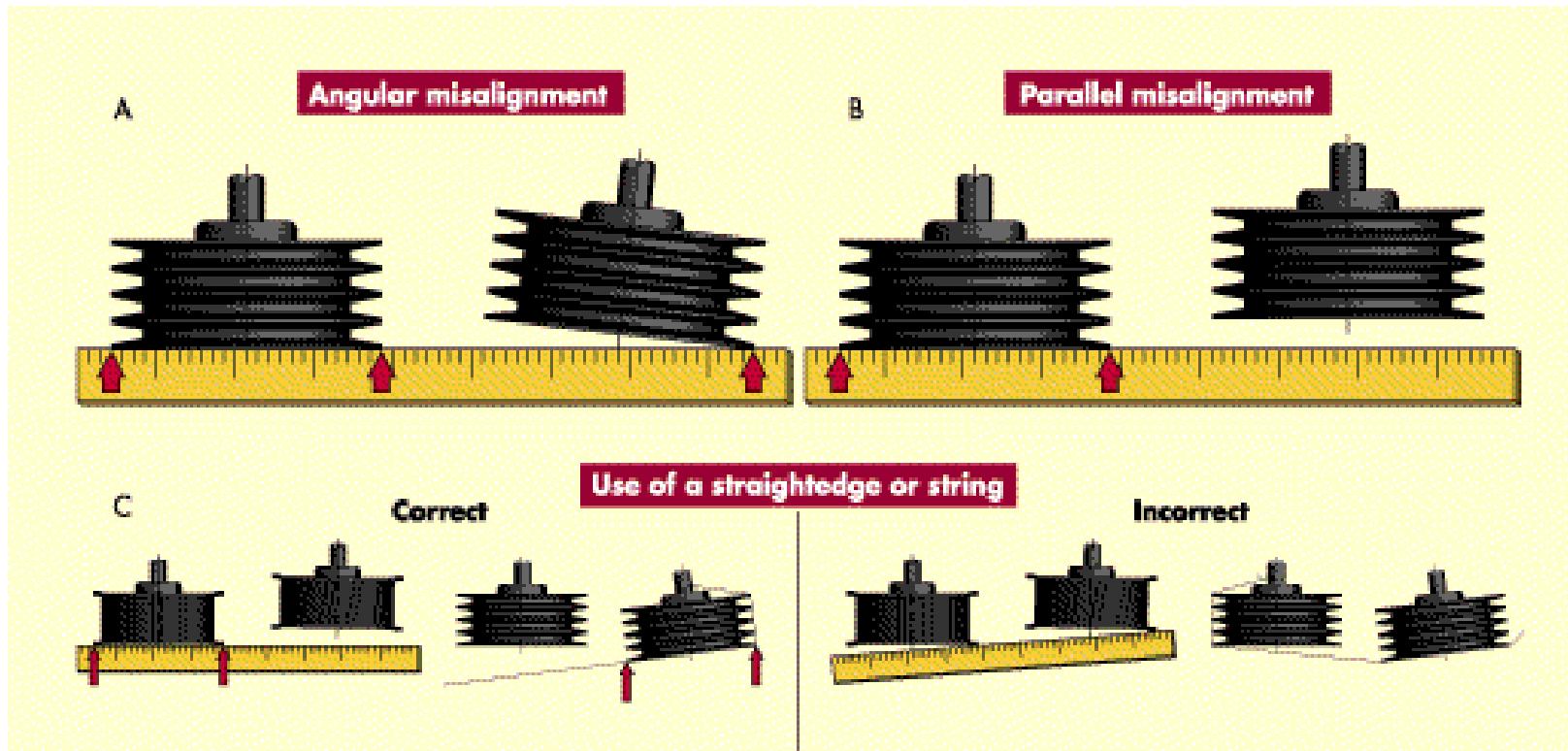
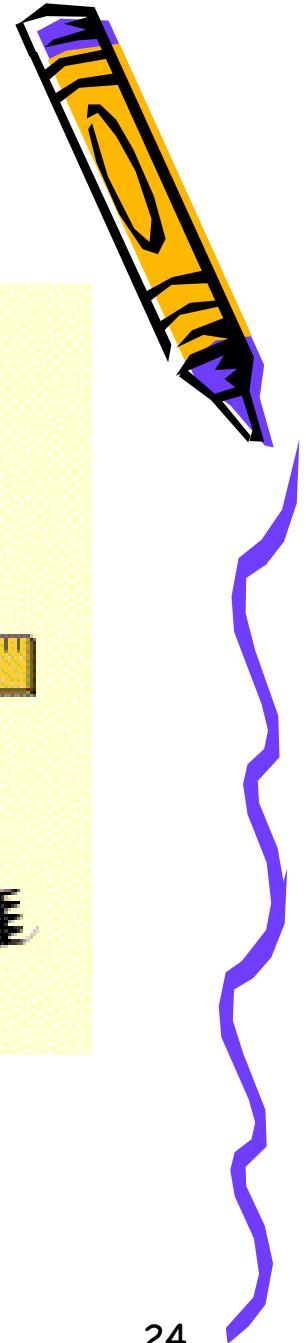


- Se manifesta in acelasi fel ca si nealinierile interne.
- Daca vibratiile au legatura cu viteza curelei sau cu multiplul acestia, problema este legata de starea si tensiunea curelei.



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Rezolvarea problemei trebuie sa tine cont de grosimea rolelor



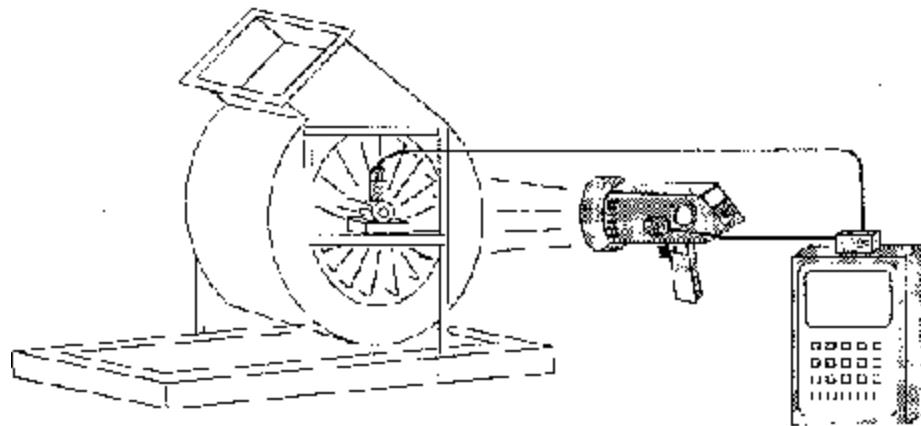
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## Detectarea dezechilibrelor si/sau nealinierii prin metoda defazajului

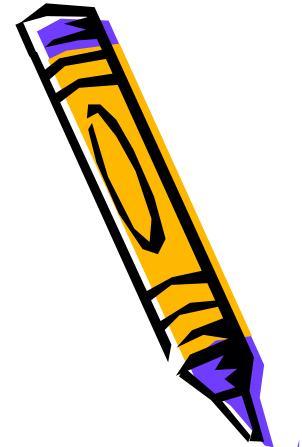
- Primul pas este acela de a localiza un punct de referinta pe arbore sau pe cuplaj.
- Se utilizeaza un analizor de vibratii echipat cu un stroboscop.



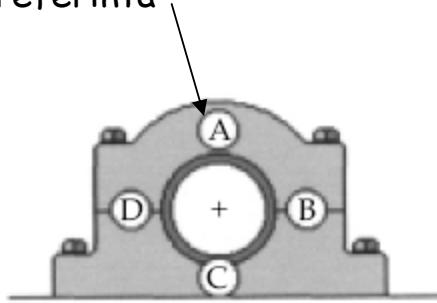
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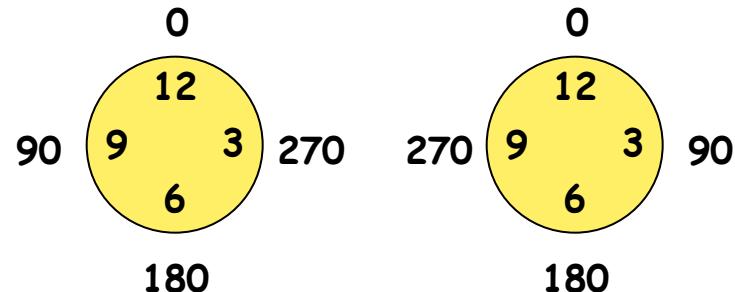
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Punct de referinta

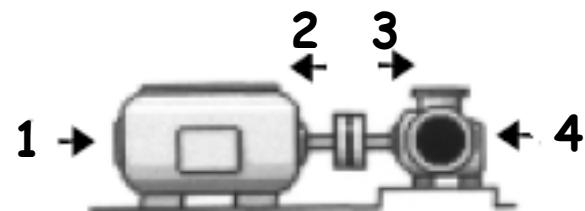


Puncte de masurare a defazajului

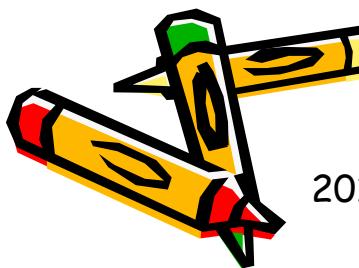
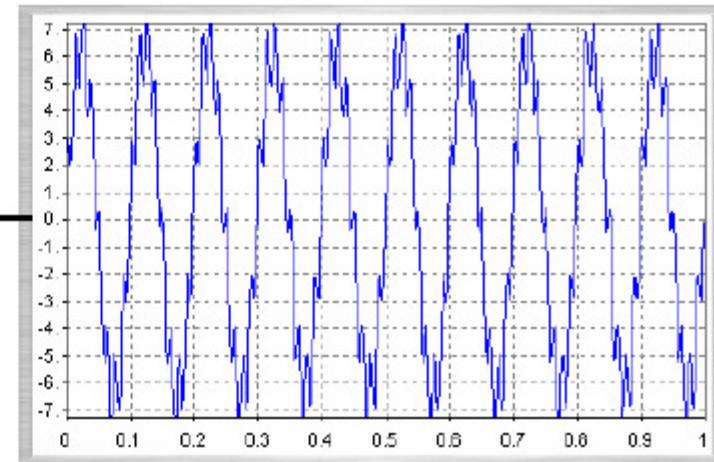
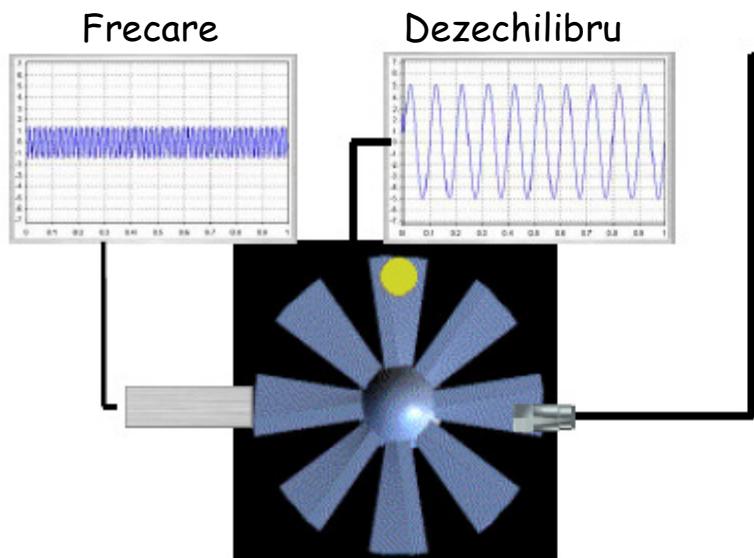


Conventie standard pentru procedura de masurare

- Se fixeaza un punct de referinta si apoi se face masurarea defazajului fata de punctul A. Se repeta pentru toate celelalte puncte (B, C, D).
- Urmatorul pas este realizarea masuratorii de partea cealalta a cuplajului prin mutarea senzorului de vibratii.
- Se realizeaza masuratori in pozitiile 1, 2, 3 si 4.



## SUPRAPUNEREA A DOUA SURSE DE VIBRATII

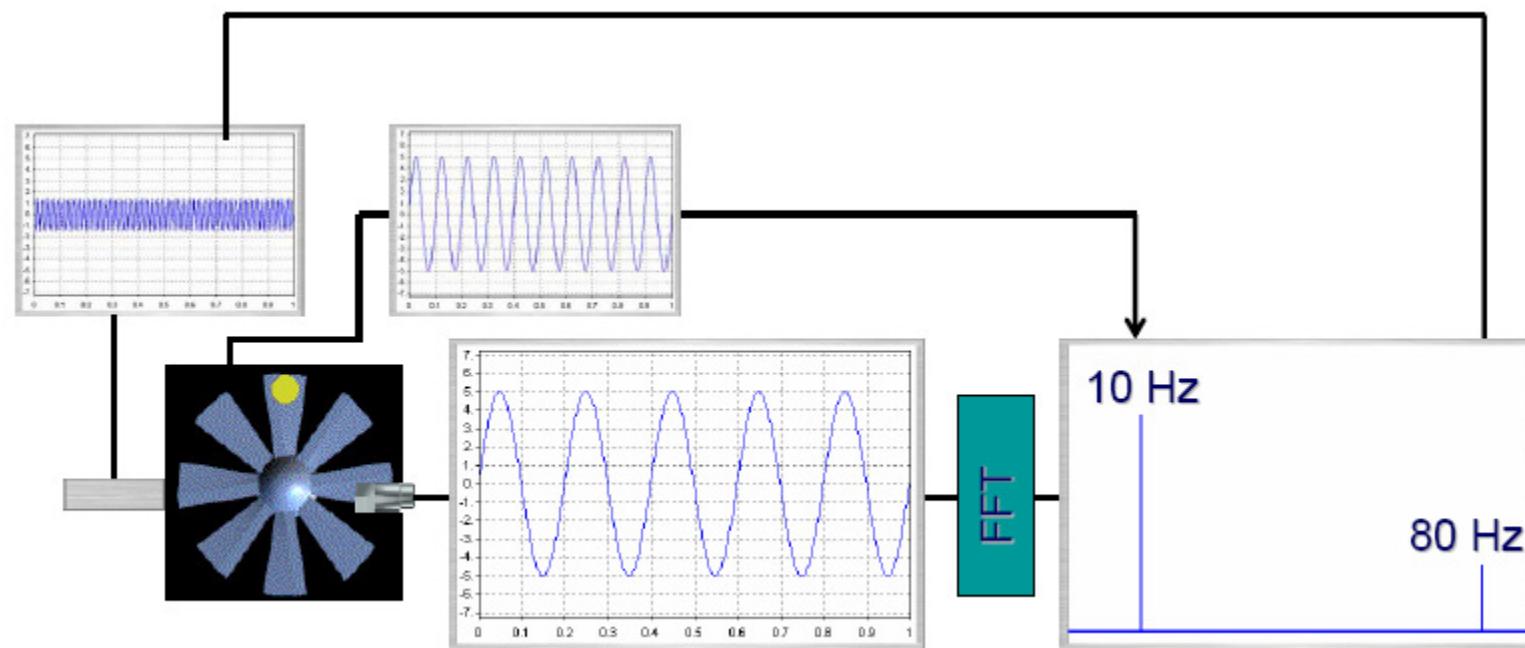


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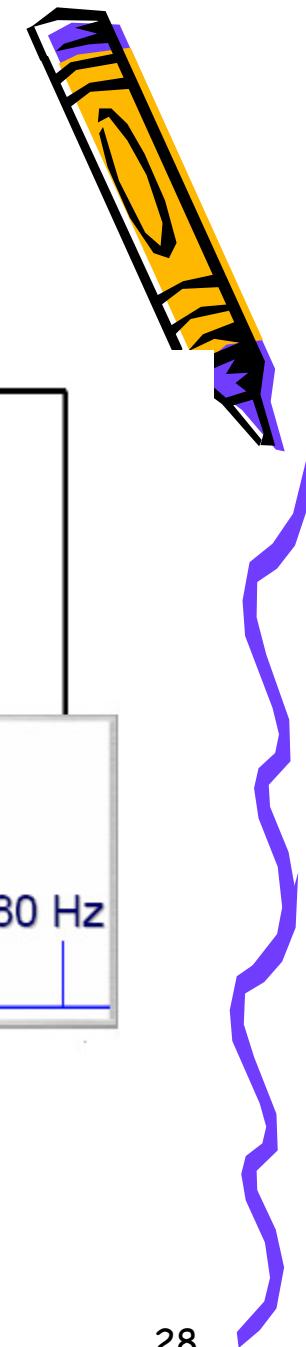
## NOUL SPECTRU



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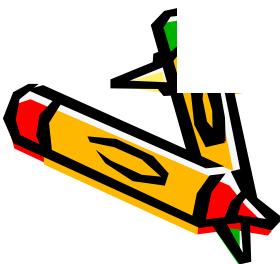
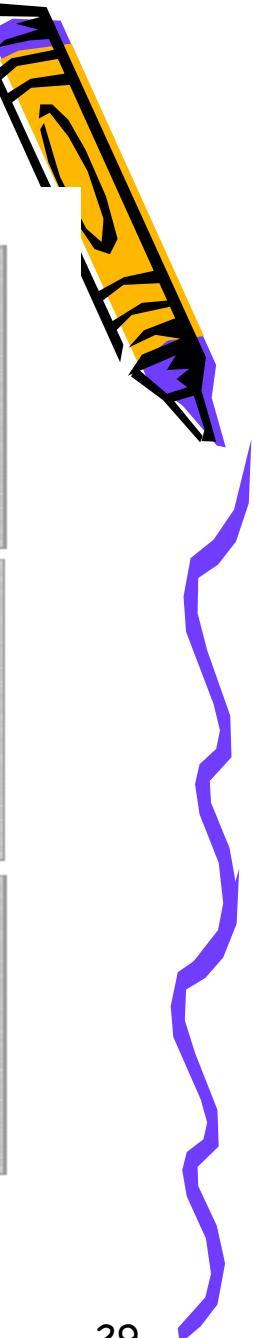
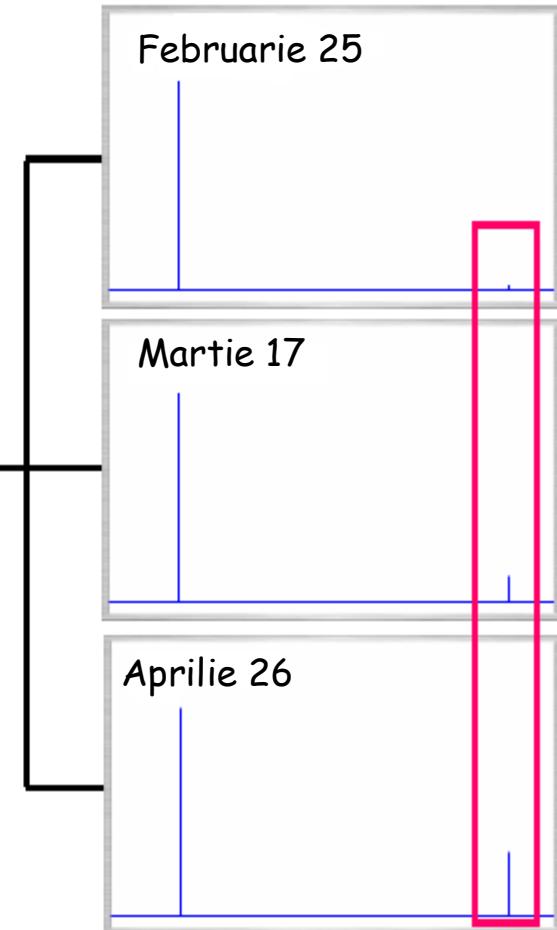
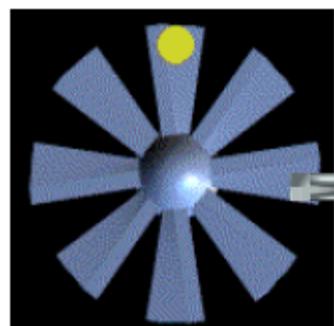
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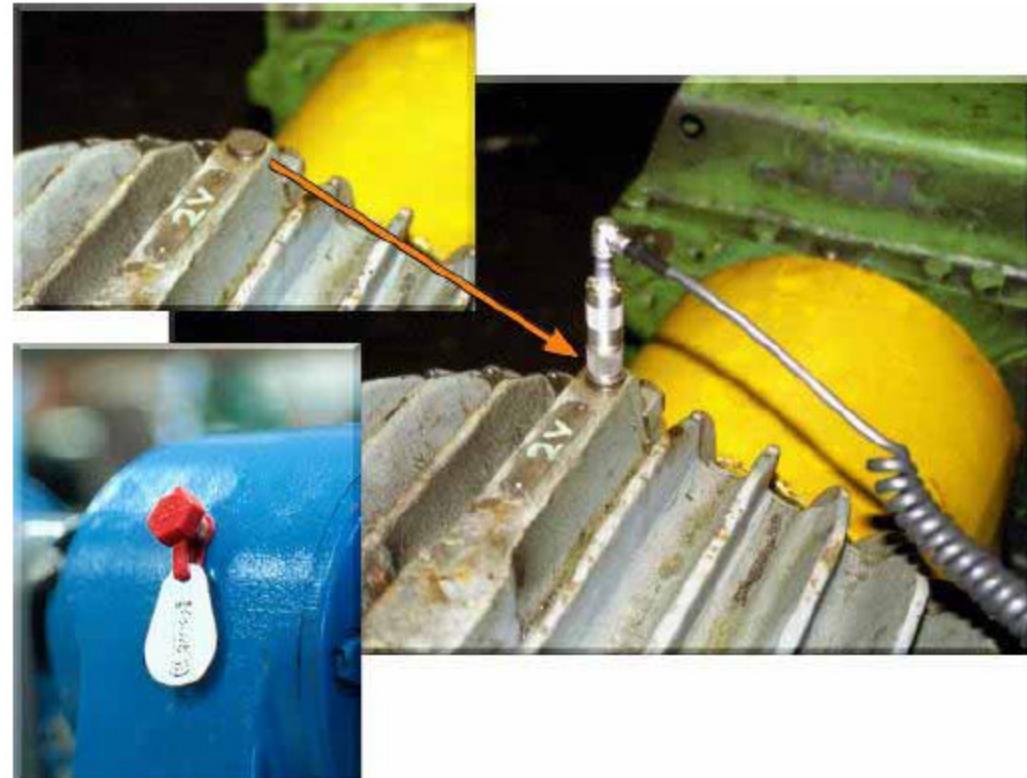


## CUM SE MONITORIZEAZA VIBRATIILE

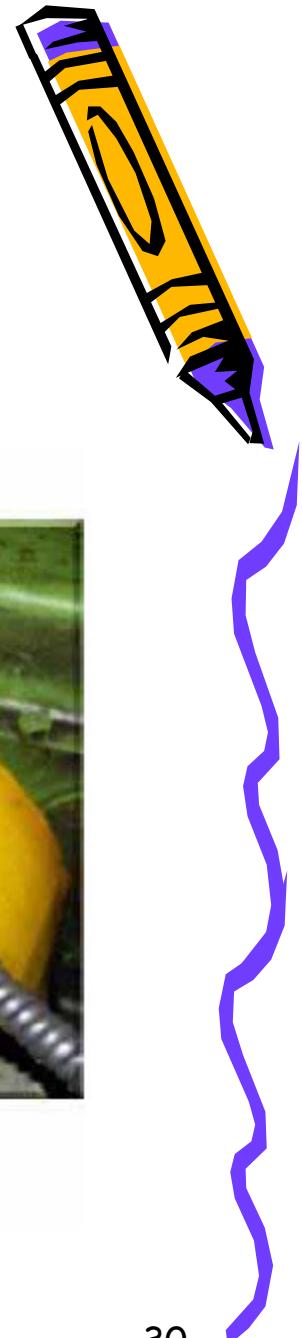
- Se urmărește frecvența și nivelul vibratiilor la intervale regulate de timp.
- Modificările se raportează la ceea ce se cunoaște despre mașina.



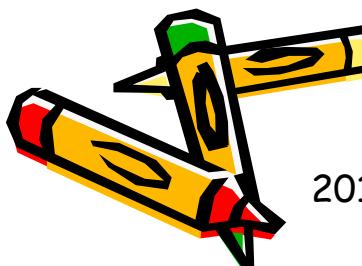
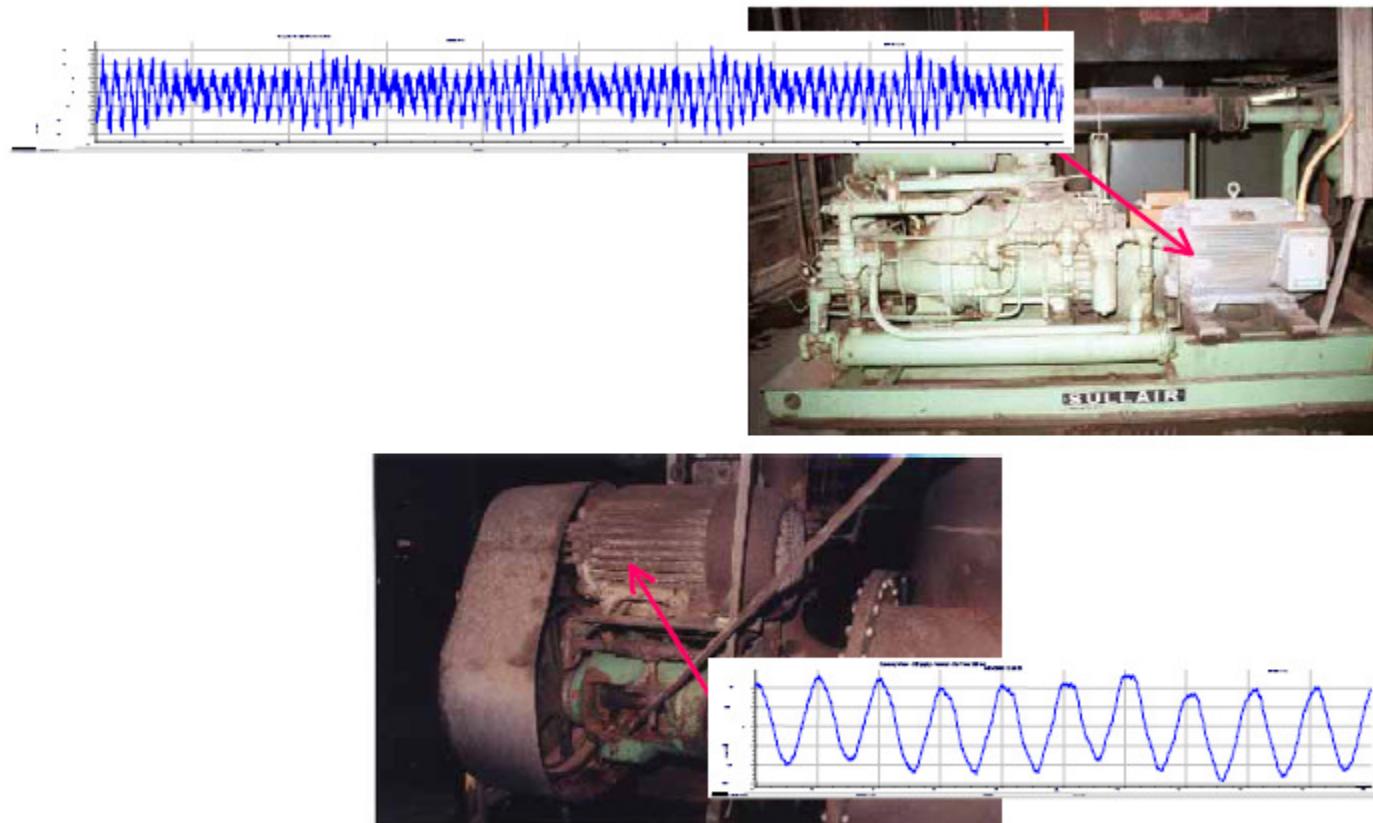
- Montarea corespunzatoare a senzorului este foarte importanta.
- Repetabilitatea este esentiala.
- Este necesar un contact foarte bun intre senzor si elementul de monitorizat.
- Testele se repeta la 30 de zile.
- Masuratorile se fac pe directie axiala, orizontala si verticala.



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➤ Monitorizarea poate avea loc continuu, urmarindu-se modificările spectrului.



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