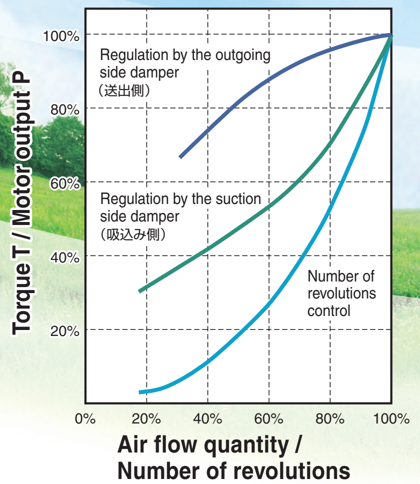
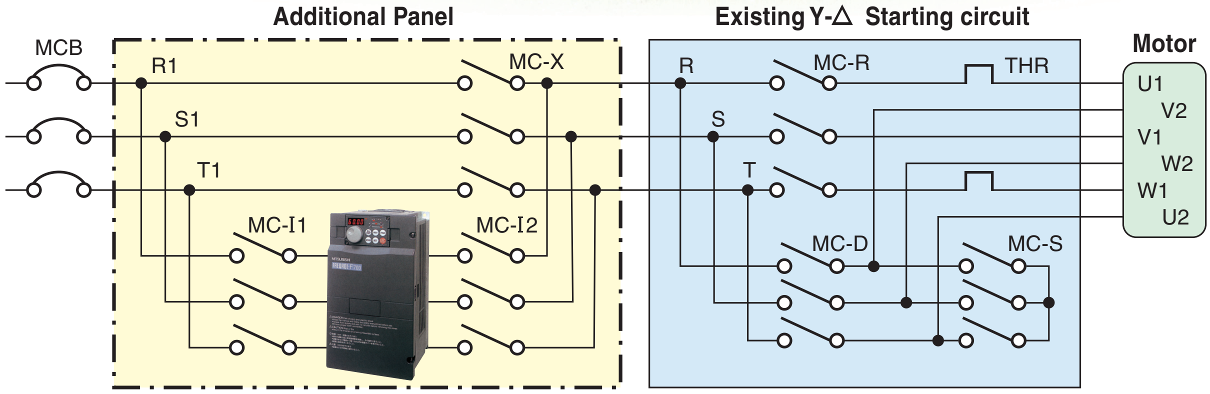
Energy-saving of the Fan / Pump equipment using an inverter
インバータ導入によるファン・ポンプ設備の省エネルギー

Proposal-Using the inverter for energy-saving
インバータによる省エネルギー提案

MITSUBISHI INVERTER FR-F/D/E 700

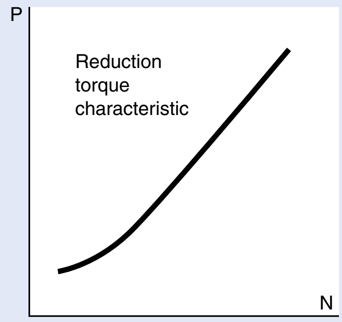




SETSUYO ASTEC CORPORATION

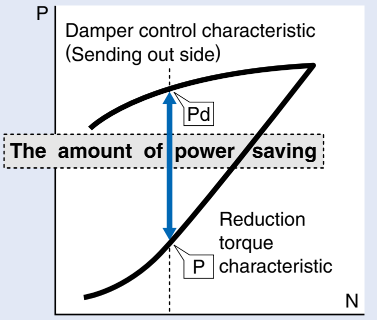
1. Characteristic of a Fan or Pump

- The volume flow of air or water is proportional to revolving speed (frequency).
  : ($Q \propto N$)
- The air pressure T, and the water lift H
  : proportional to the square of revolving speed N ($T \propto H \propto N^2$)
- Motor output P : $P = K1 \times Q \times T$ or H [kW]
- Motor power P : proportional to a cube of revolving speed N ($P \propto N^3$)
  $\therefore P = K3 \times N^3$ [kW]
- Load characteristic of a Fan or Pump: Reduction torque load
  ——— Right figure



2. Point of energy saving in a Fan or Pump

- For fans and pumps that are fed by commercial power, in order to fix the speed of the motor, a common way is to adjust (control) the volume of air / water flow.
- However, even if this system lowers flow volume loss by the damper or a valve occurs and reduction of the axis power of motor cannot be expected.
- To solve this issue, you can use an inverter to adjust the motor speed.
  By controlling the motor speed, you can adjust the flow volume.
- Since the motor output P will be reduced according to a cube of revolving speed, if this method is adopted, big energy saving can be expected.
- Amount of power saving : $Ps = Pd - P$ [kW]



3. Example of effect of energy-saving (in case of a fan used in Japan)

Rated specification of equipment
- Quantity of the rated flow : 1300 [m^3/min]
- Motor rating output Pr : 132 [kW]

Before the measure
- Air volume was adjusted with the damper.
  : Actual air volume
  : 800 [m^3/min]
- Number of revolution ratio
  = actual quantity /rating quantity
  : 800 / 1300 = 0.615
  : 61.5 [%]
- Motor actual power : 100 [kW]

After the measure
- The damper was fully opened (100 [%]), the inverter control was introduced, and air volume was adjusted by the number of revolutions of the fan's motor.
- Output frequency corresponding to actual air volume.
  : Rated frequency × number – of – revolutions ratio = 60 [Hz] × 61.5 [%] = 37 [Hz]
- The actual output P of a motor.
  : Motor actual power × (number – of – revolution ratio)^3 =
  : 132 [kW] × $(0.615)^3$ = 30.8 [kW]
- Considering loss of an inverter (about 10 [%]), the output Pi when controlled by the inverter : P ×1.1 = 30.8 [kW] × 1.1 = 33.8 [kW]
- Improved power Ps of the fan : Pr – Pi : 100 [kW] – 33.8 [kW] = 66.1 [kW]

Improvement effect
- Electric energy reduced / year (Operating condition : 12 hours / day, 300 days / year)
  : 66.1 [kW] ×12hour × 300day = 237,960 [kWh]
- Electric energy cost reduced / year (Power rate = 13 [yen/kWh])
  : 237,960 [kWh] × 13 [yen/kWh] = ¥3,093,480–
- Investment cost for the measure taken
  : Unit and installation costs of inverter panel = ¥4,080,000 –
- Investment effect : Will pay for itself in 1.3 years

Investment cost for the measure
- Inverter and option apparatus
- Manufacturing / installation of the control panel
- Modification of the existing control panel (Main circuit / Control circuit / PLC programming)
- Electrical work : Wiring work

Check Point

(1) Is the air/water flow controlled ?
- Check by the actual system — Cannot be controlled if the resistance of air duct / pipe is large and the damper / valve is fully (100 [%]) opened.

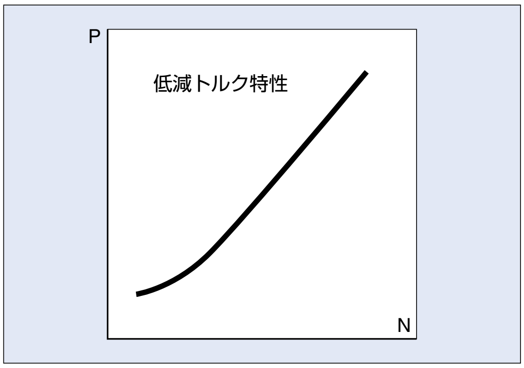
(2) Does motor rating current (Im) have the margin (about 10 [%]) compared with real load current (Ir) ?
- Check the motor rating plate and the measured current value — $(Ir) < 0.9 \times (Im)$

(3) Is the inverter rating current (Iinv) larger than 110 [%] × motor rating current (Im) ?
- Check the motor rating plate and the catalog. — $(Iinv) > 1.1 \times (Im)$

(4) Does the fan/pump have the reduction torque characteristic suitable for energy saving ?
- Check to the maker of the fan / pump.

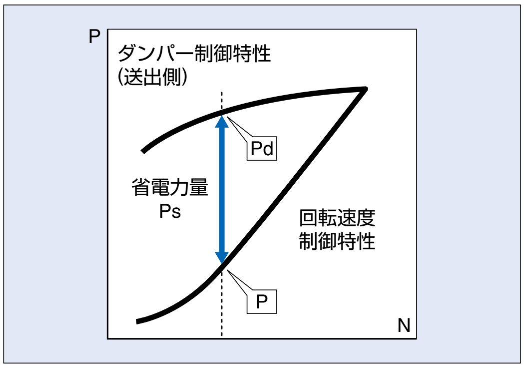
1. ファン・ポンプの特性

- 気体や液体の流量は回転速度(周波数)に比例 ($Q \propto N$)
- 気体の風圧Tや液体の揚力H：回転速度Nの2乗に比例 ($T \propto H \propto N^2$)
- モータ出力P：$P = K1 \times Q \times T$ or H〔kW〕
- モータ軸動力P：回転速度Nの3乗に比例 ($P \propto N^3$)
  $\therefore P = K3 \times N^3$〔kW〕
- ファン・ポンプの負荷特性：低減トルク負荷 ―――― 右図



2. ファン・ポンプの省エネルギーのポイント

- ファン・ポンプの商用電源の運転においては、モータを一定の速度で運転するため、気体や液体の流量をダンパーやバルブで調節(制御)する方式を一般的に採用しています。
- しかしながら、この方式は、流量を下げてもダンパーやバルブでの損失が発生し、モータ軸動力Pdの低減が余り期待できません。
- 一方、モータをインバータで駆動して回転速度を変化させて、流量を調節する回転速度制御方式があります。
- この方法を採用すれば、モータ出力Pは回転速度の3乗に従って低減するので、大幅な省エネルギーを図ることができます。
- 省電力量$Ps = Pd - P$〔kW〕



3. 省エネルギーの効果 の実例 （ファンの場合、日本における事例）

設備の定格仕様	●定格風量：1300〔m³/min〕　●モータ定格出力Pr：132〔kW〕
対　策　前	**対　策　後**
●ダンパーで風量を調節した。 ：実際の風量 ：800〔m³/min〕 ●回転数比＝実際の風量 / 定格風量 ：800 / 1300 ＝ 0.615 ：61.5〔%〕 ●モータ実出力：100〔kW〕	●ダンパーを全開(100〔%〕)にして、インバータ制御を導入し、風量の調節をファンの回転数で行った。 ●実際の風量に対応した出力周波数 ：定格周波数 × 回転数比 ＝ 60〔Hz〕× 61.5〔%〕＝ 37〔Hz〕 ●モータの実出力P ：定格出力 × (回転数比)³ ＝ ：132〔kW〕× (0.615)³ ＝ 30.8〔kW〕 ●インバータの損失を約10〔%〕と考えると、インバータ制御時の出力Piは、 ：P ×1.1 ＝ 30.8〔kW〕× 1.1 ＝ 33.8〔kW〕 ●改善したファンの電力Ps：Pr － Pi：100〔kW〕－ 33.8〔kW〕＝ 66.1〔kW〕

改 善 効 果	対策投資費用
●年間の削減電力量 (運転条件: 1日12 時間、年間300日稼動する) ：66.1〔kW〕×12時間 × 300日 ＝ 237,960〔kWh〕 ●年間の削減電気料金 (単位電気料金 = 13〔円/kWh〕とすると) ： 237,960〔kWh〕× 13〔〔円/kWh〕 ＝ ￥3,093,480－ ●対策投資：インバータ盤費用 ＋ 電気工事費 ＝ ￥4,080,000 － ●投資効果：1.3年で回収可能	●インバータ及びオプション機器 ●制御盤の製作／据付 ●既存制御盤の改造 (主回路 / 制御回路 / PLCプログラミング) ●電気工事：配線工事

● 確 認 事 項

(1) 流量は制御されているか。
　• 実機で確認する。―― エアーダクト/配管の抵抗が大きく、ダンパ/バルブ開度が100〔%〕の場合は制御できない。
(2) 実負荷電流(Ir)に比べモータ定格電流(Im) は余裕(約10〔%〕)を有しているか。
　• モータ定格名板と実測電流値を確認する。―― $(Ir) < 0.9 \times (Im)$
(3) インバータの定格電流(Iinv) ＞ ＝ モータの定格電流(Im)の110〔%〕以上?
　• モータ定格名板／カタログで確認する。―― $(Iinv) > 1.1 \times (Im)$
(4) ファン／ポンプは省エネルギーに適した低減トルク特性を有しているか?
　• ファン／ポンプのメーカに確認する。

Estimation sheet of energy-saving (Fan / pump)
省エネルギー予測検討書（ファン/ポンプ設備）

■ We offer this sheet in Excel.

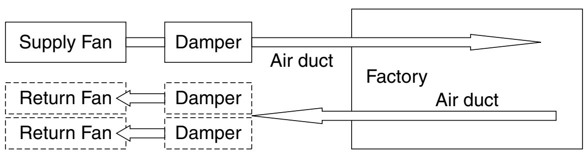
ファン・ポンプの省エネルギー計算書
Calculation sheet for reduced energy for fan / pump

設備名　Equipment name：

数値入力部：Numerical input part
計画値 / 設計値：Plan value & Design value
実測値 / 見積値：Actual measurement & Estimated value

実施手順 Procedure	項　目 Item	計算式 Formula	計算事例：Example 用途：Air handling Supply Fan		計算書：Account Use 1：	
1.設備定格の把握 Understand rated values of the equipment	定格風量　：Rated air volume	Qr〔m³/h〕	1300.0			
	同上　台数：Same as the above　Number	n	1.0			
	同上　合計：Same as the above　Total	Qt〔m³/h〕= Qr × n	1300.0			
	モータ定格出力：Rating output of a motor	P〔kW〕	132.0			
	同上　台数：Same as the above　Number	m	1.0			
	同上　合計：Same as the above　Total	Pt〔kW〕= P × m	132.0			
	定格電圧　：Rated voltage	V〔V〕	400.0			
	定格電流　：Rated current	I〔A〕= P × 1000 / (Root3 × V × COSφ)	228.0			
	周波数　：Frequency	f〔Hz〕	50.0			
	極数　：Number of poles	Pole	4.0			
	定格回転数　：Rated number of revolutions	Ns〔rpm〕= 120 f / Pole	1500.0			
	力率　：Power factor	COSφ〔%〕= P / (Root3 × V × I)	83.7			
2.設備の実値把握 Understand the actual values of the equipment	実　風量　：Actual air volume <測定値　：Measured value>	Q〔m³/h〕 全台数合計値：Total value	800.0			
	実風量比　：Ratio of actual air volume	W〔%〕= (Q / Qt) × 100	61.5			
	実　電圧　：Actua l voltage <測定値　：Measured value>	Vr〔V〕	400.0			
	実　電流　：Actual current <測定値　：Measured value>	Ir〔A〕	172.7			
	実　回転数：Actual number of revolutions <測定値　：Measured value>	Nr〔rpm〕	1450.0			
	モータ実出力　：Actual motor output	Pr〔kW〕= Root3×Vr×Ir×COSφ/1000	100.0			
	同上 合計出力：Same as the above　Total output	Prt〔kW〕= Pr × m	100.0			
3.省エネルギー予測 Estimated energy reduction	低減周波数　：Reduced frequency	fa〔Hz〕= f × W / 100	36.9			
	ＩNV制御時出力：Control output	Pic〔kW〕= Pt × (W / 100) 3rd power	30.8			
	ＩNV損失考慮時の出力：Actual control output	Pi〔kW〕= Pic × (1.1)	33.8			
	同上　合計出力：Total output	Pit〔kW〕= Pi × m	33.8			
	省電力　：Power saved	Ps〔kW〕= Prt − Pit	66.1			
	1日の稼動時間　：Operating hours / day	Hour / (a day)	12.0			
	年間の稼動日数：Operating days / year	Days	300.0			
	年間省電力量　：Power saved / year	Py〔kWh〕= Ps × Hour × Days	238125.8			
	合計省電力量　：Total power saved	Py〔kWh〕		238125.8		
	電力料金単価　：Power rate	Pu〔¥/kWh〕		13.0		
	年間省電力費用：Cost for power-saving / year	MS〔¥〕= Py × Pu		3095636.0		
4.投資効果の把握 Understand the effect of the investment	インバータ盤費用：Inverter panel cost	C1〔¥〕		3708000.0		
	電気工事 / 現地調整費用：Electric work / on-site adjustment cost	C2〔¥〕		300000.0		
	設備投資額：Amount of capital investment	M〔¥〕= C1 + C2		4008000.0		
	回収期間　：Collection period	Y = M / Ms		1.3		

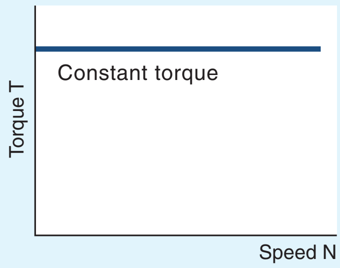
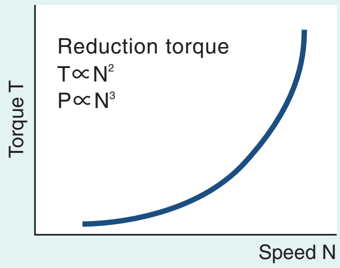
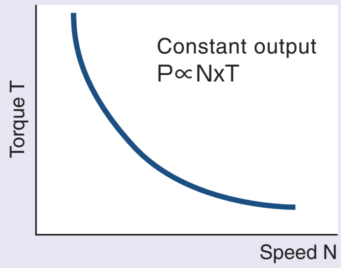
(1)計算事例説明：Explanation of calculation example
(a)システム構成：System configuration



■ We can review the sheet you created, if necessary.
作成はお客様にてできるようになっておりますが、必要に応じ弊社にてチェック致します。

■ We also offer support services for a filed survey / sheet creation.
また、弊社においても現地調査 / シート作成を協力できます。

Load characteristic and the Mitsubishi Electric inverter <FR-A/F/D/E 700> of equipment

Load characteristic	① Constant torque 定トルク	② Reduction torque 低減トルク	③ Constant output 定出力
Use	Crane / Hoist / Lifter Elevator / Traverser Conveyor / Cart / Machine tool	Fan / Pump	Reel / Winder Pay Off Reel(POR) / Rewinder
Feature	Regardless of speed, torque is almost fixed.	The load torque T is proportional to the square of number of revolutions N.	Torque T and number of revolutions N have an inverse proportion relation and output of product is fixed.
	In case the load is subject to vertical movement or friction, torque T is almost fixed regardless of speed V. ● $V \propto N$ ● Motor output $P \propto NxT$	Fan's air pressure H or power of a pump H is proportional to the square of number of revolutions N. ● $T \propto H \propto V^2 \propto N^2$ ● Motor output $P \propto NxT \propto N^3$	In Winder / rewinding machine, when operating at speed V under the condition of tension S being fixed, the reel output VxS also becomes fixed. ● $V \propto N$, $S \propto T$ ● Motor output $P \propto VxS \propto NxT$
Characteristic curve of Speed / Torque			
Selection apparatus	● FR-A700 (0.4-500〔kW〕) ● FR-D700 (0.1-15〔kW〕) ● FR-E700 (0.1-15〔kW〕)	● FR-F700 (0.75-560〔kW〕) ● FR-D700 (0.1-15〔kW〕) ● FR-E700 (0.1-15〔kW〕)	● FR-A700 (0.4-500〔kW〕) (Vector inverter)
	● Reduction torque control is also possible.	● Constant torque load control is also possible.	● The motor for vector control is required.
Aim of introduction	Better efficiency Energy-saving with light load	Energy saving of fan / pump equipment	Highly advanced / precise control

● Mitsubishi Electric FA apparatus homepage : please refer to MELFANSweb.
http://wwwf2.mitsubishielectric.co.jp/melfansweb/

Contact

NANE	ADDRESS	TEL / FAX
SETSUYO ASTEC CORPORATION **JAKARTA REPRESENTATIVE OFFICE**	NUSANTARA BLDG., 14TH FLOOR, JL.M.H. THAMRIN NO.59 JAKARTA, 10350 INDONESIA	TEL +62-21-3193-6292 FAX +62-21-3193-0378
SETSUYO ASTEC CORPORATION **MANILA OFFICE**	7TH Floor Athenaeum Building 160 L.P. Leviste Street Salcedo Village Makati City, Philippines 1227	TEL +63-2-892-5571 FAX +63-2-894-4382
SETSUYO ASTEC CORPORATION／ **SA GIANG TRADING CO. LTD.** **HO-CHI-MINH OFFICE**	10TH Floor, Room 1004-1005, Building 255 Tran Hung Dao St,Co Giang Ward, District 1, Ho Chi Minh City, Vietnam	TEL +84-8-8386931 FAX +84-8-8386932
SETSUYO ASTEC CORPORATION／ **SA GIANG TRADING CO., LTD.** **HA NOI REPRESENTATIVE OFFICE**	NO561 KIM MA STREET, BA DINH DISTRICT, HA NOI CITY, VIET NAM	TEL +84-4-7712378 FAX +84-4-7712379

SETSUYO ASTEC CORPORATION
1-29, MINAMIMORIMACHI 2-CHOME E KITA-KU, OSAKA 530-0054 JAPAN
TEL +81-6-6130-0152 / FAX +81-6-6130-0157

AGENCY

STC-002 (2009.8) MDOC
2009年8月作成