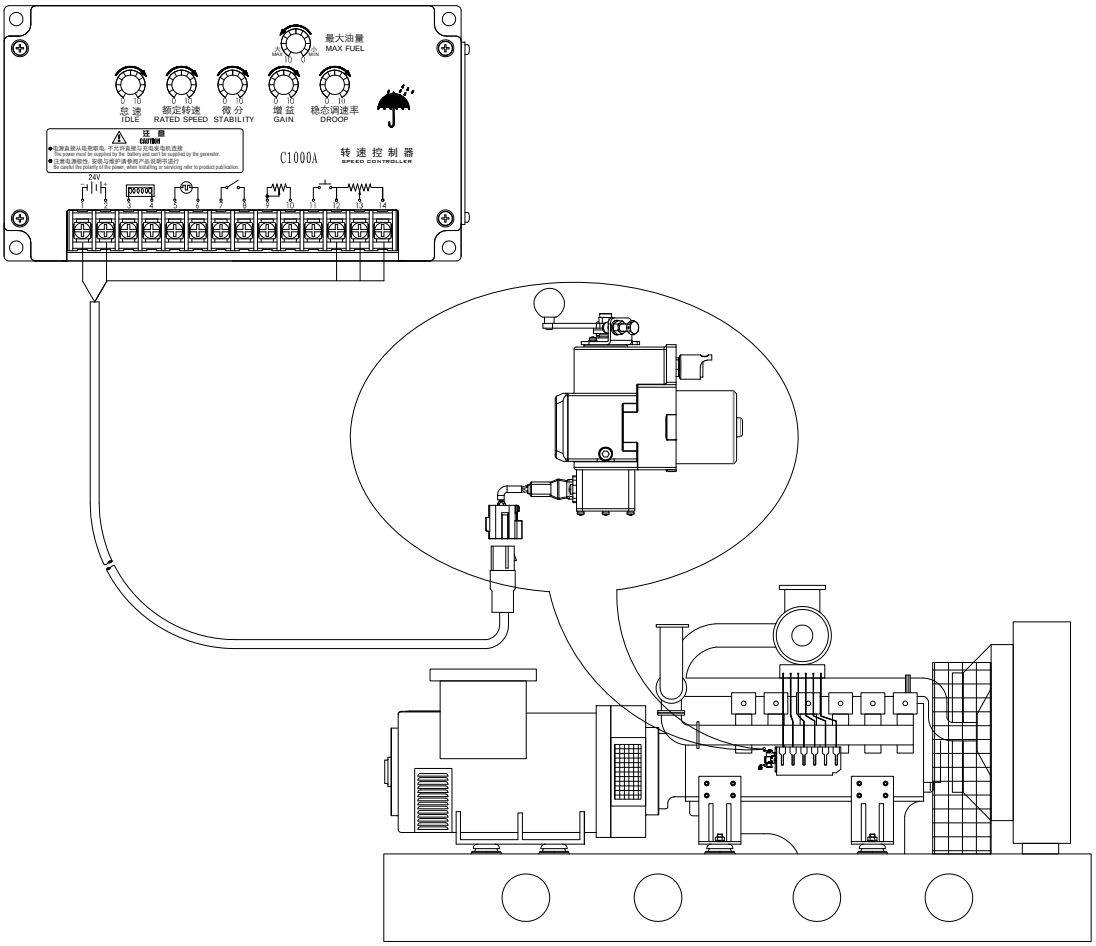
ESG1000 系列
ESG1000 Series
电子调速器使用说明书
Electronic Governor Instruction



前 言

本使用说明书主要介绍了电子调速系统的工作原理、组成、调节、操作、维护及简易故障的排除方法等，适用于对发动机及电子调速器有一定了解、日常进行安装、接线、使用及维修的工作人员。建议将本说明书置于产品的工作场所，并严格遵循这里所提供的方法去操作。

警 告

- 本电子调速系统中所使用到的转速传感器不得与其他系统共用，否则将有可能造成严重后果。
- 您不能完全依靠本电子调速系统来防止发动机超速，而应在发动机系统上安装独立、有效的超速保护装置。
- 发动机起动之前应确认喷油泵供油杆处于断油的位置，推拉供油齿杆应灵活无卡涩。

目　录

1 电子调速器的工作原理

发动机电子调速器是将发动机控制在设定工作转速下稳定运行的精密控制装置。电子调速器因其性能可靠、功能齐全、安装维护方便以及调速性能优异等有别于其它类型调速器的独特优势，正越来越广泛地应用于发动机调速系统、发电机组监控系统之中，成为行业应用的一种发展趋势。

电子调速器具有转速设定、测速、比较、运算、驱动输出、执行元件、调节系数设定、超速保护或限制等机构或部件，各机构或部件经过有效组合形成一个闭环控制系统(如图 1.1 所示)：

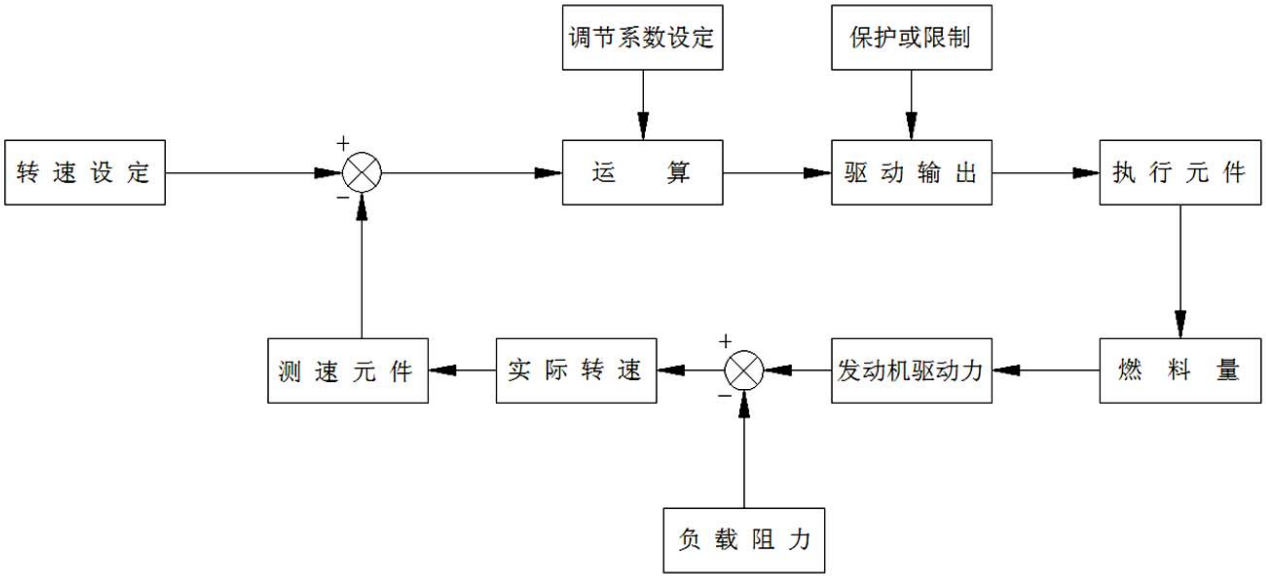


图 1.1 电子调速器工作原理示意图

电子调速器的闭环控制方式能够对发动机瞬间负荷变化产生快速和精确的响应，用以控制发动机的转速趋向稳定。通过手动调整控制器增益、微分以及稳态调速率电位器等可满足不同发动机对于瞬态调速率、稳定时间和稳态调速率的需求。

电磁执行器是电子调速器的执行部件，通过转速控制器控制电磁执行器线圈的电流，可以控制执行器的输出位移。电磁执行器直接驱动柴油机的高压油泵齿条或汽油机、气体机的节气门，从而控制发动机的燃料供给量。通过热力转换，发动机将化学能转化为动能，输出动力扭矩，动力扭矩与负载阻力矩相互作用形成发动机的转速输出。因此，控制电磁执行器的电流大小即可控制发动机的转速。

发动机的理想转速由转速设定电位器和外接微调电位器设定，发动机的实际转速由安装于飞轮齿圈部位的磁电式转速传感器所感受，其输出信号为频率与发动机转速成比例的交流电压信号；该信号经 F/V

电路转换为直流电压，与转速设定值比较后得到转速偏差量；该偏差经 PID1 调节器运算放大后得出发动机燃料供给量位置值，即执行元件稳态输出指令位置，该指令位置与当前电磁执行器实际输出位置比较后，得到位置偏差量，该偏差再经过 PID2 调节器运算放大后，转化成 PWM 电流控制方式，向电磁执行器输出驱动电流，以改变电磁执行器的输出位移，驱动发动机喷油泵齿条、节气门或燃料控制阀向减小转速偏差的方向运动，从而控制发动机在所设定的转速下稳定运行。

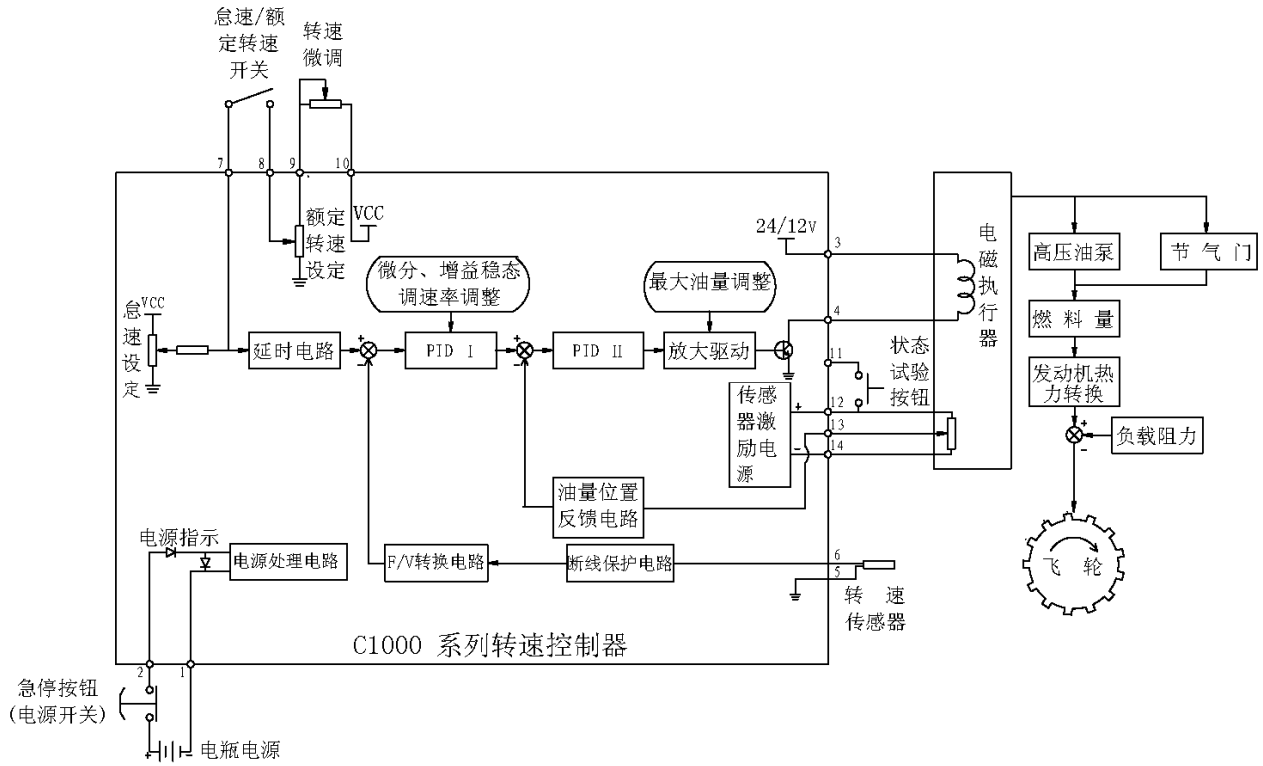


图 1.2 ESG1000 系列电子调速器控制系统原理图

2 电子调速系统的组成

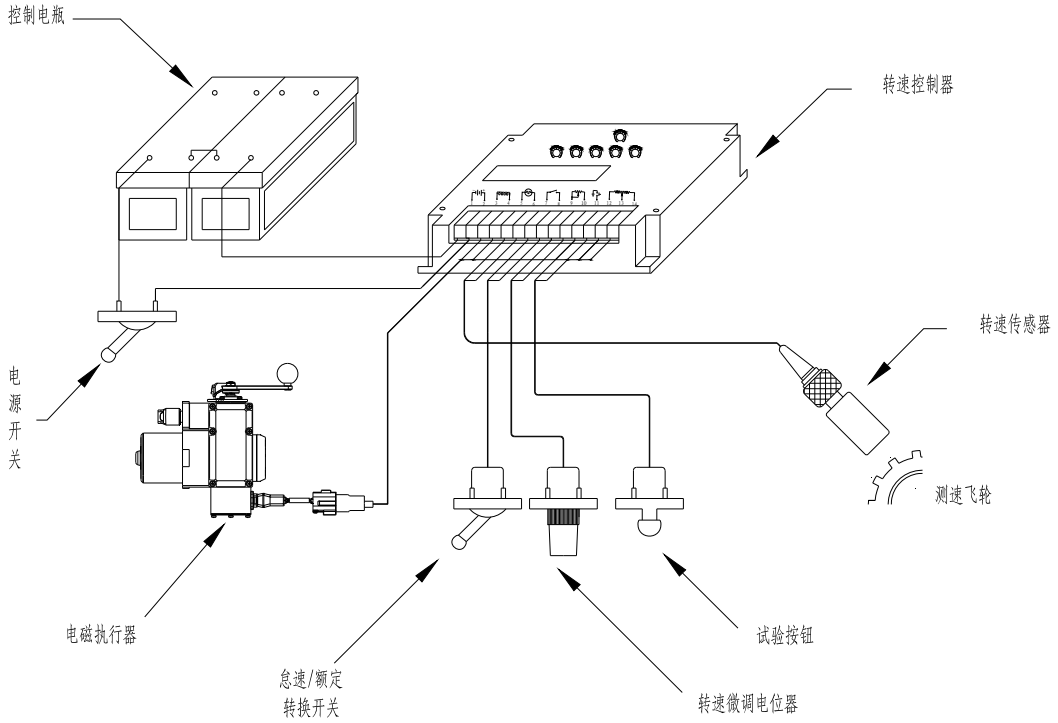


图 2.1 ESG1000 系列电子调速器基本系统组成图

2.1 C1000 型转速控制器(SPEED CONTROLLER)

2.1.1 基本电气特性

☑ 电源电压： DC24V（范围 18V～32V）

DC12V（作为特殊订货）

☑ 电源消耗： 〈 0.1A（不包括执行器）

☑ 控制频率： 1000～13000Hz

☑ 转速波动率： ≤ ±0.25 %

☑ 稳态调速率： 0～5 % 可调

☑ 瞬态调速率： ≤ 10 %

☑ 环境温度： -40℃～ +70℃

☑ 环境湿度： 〈 95%

☑ 防护等级： IP44

2.1.2 C1000 型转速控制器的基本功能

- 最大油量限定 ：限定油泵的最大喷油量，防止发动机超额使用；
- 转速控制及转速微调 ：采用双闭环方式控制转速，转速可精确调节、遥控；
- 高低速转换 ：可在怠速工况与额定工况之间进行切换；
- 稳态调速率（速降）可调 ：稳态调速率范围可调；
- 并机功能 ：可通过手动并机功能来实现多台机组的并联工作；
- 全程调速 ：可实现在一定范围内的转速之间连续、平滑的调整；
- 自动停车保护 ：当转速信号消失、控制器掉电时，使发动机自动停机；

以上基本功能的实现可参考后续章节参数设置中的详细说明，其中全程调速功能根据用户对转速调节范围的不同要求，可能需要配置不同的外接配件，如果用户有对该项功能的需要，请联系我们。

2.1.3 C1000 型转速控制器的功能扩展

C1000 型转速控制器除了具有以上基本功能外,还在内部集成了如转速范围、A/B 板及气体机等功能，这些功能都可在控制器内部通过更改不同的跳线位置来设定。该转速控制器的突出特点是使用双闭环控制电路，转速滤波电容冗余设计，使其调速性能更好，功能更多，安装维护方便，可靠性高。

- TP1：转速设定电压监测点，采集电压为 V1，V1 应等于反馈转速电压 V2；
- TP2：反馈转速电压监测点，采集电压为 V2；
- J1 ：控制频率范围跳线设定 N1(1M)：≤ 1700Hz；N2(2M)：≤ 3400Hz
  N3(4M)：≤ 7800Hz；N4(8M)：≤ 13000Hz。
- J2 ：适应不同位置反馈器的 A/B 板设定 a：C1000A 转速控制器；
  b：C1000B 转速控制器。
- J3 ：适用于气体机控制 c：C1000A 或 C1000B 转速控制器；
  d：供气体机用的 C1000-Q 型转速控制器。
- J4 ：高低速切换时间选择跳线 e:延时增加约 3 秒；
  f:延时增加约 10 秒；

注意：以上各可选跳线端子的跳线设定，同一个跳线端子只允许有一处跳线，而不能在同一个跳线端子上同时有多处跳线，否则将可能造成严重后果，非专业人士不得进行操作。

2.1.4 C1000 转速控制器外形及安装尺寸(如图 2.2 所示)

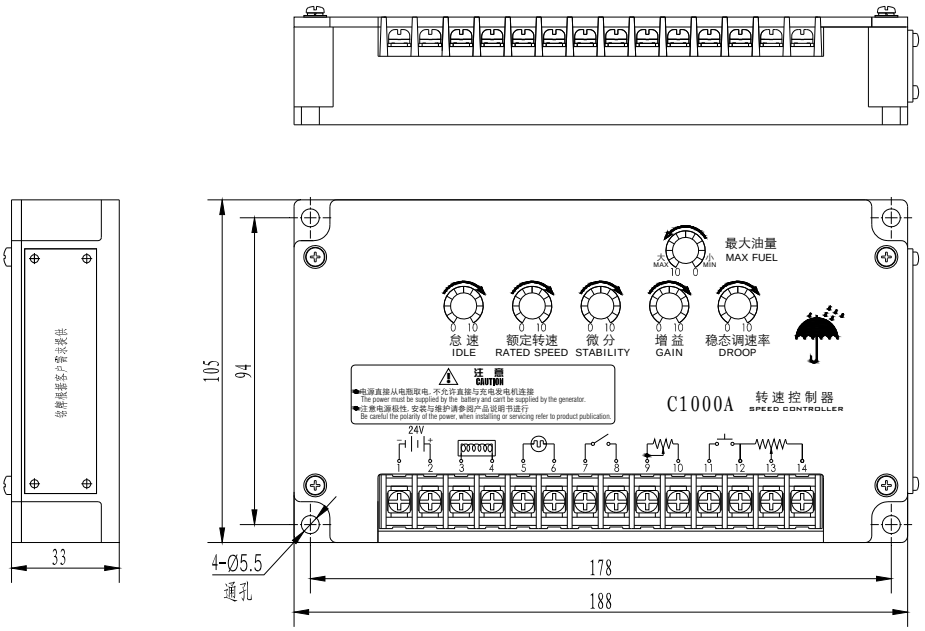


图 2.2.1 C1000A 转速控制器外形及安装尺寸

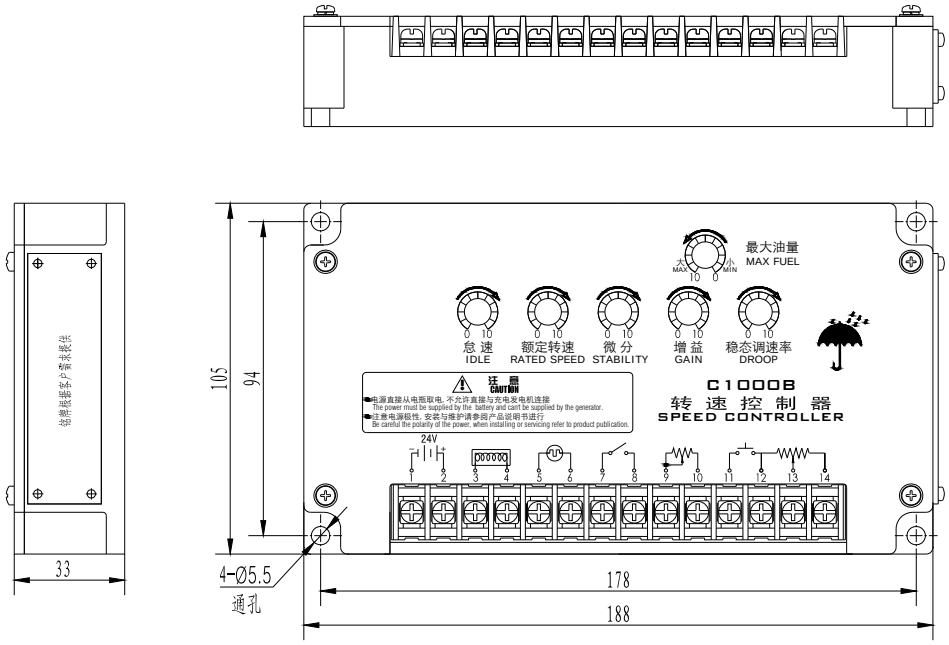


图 2.2.2 C1000B 转速控制器外形及安装尺寸

2.1.5 C1000 转速控制器接线图(如图 2.3 所示)

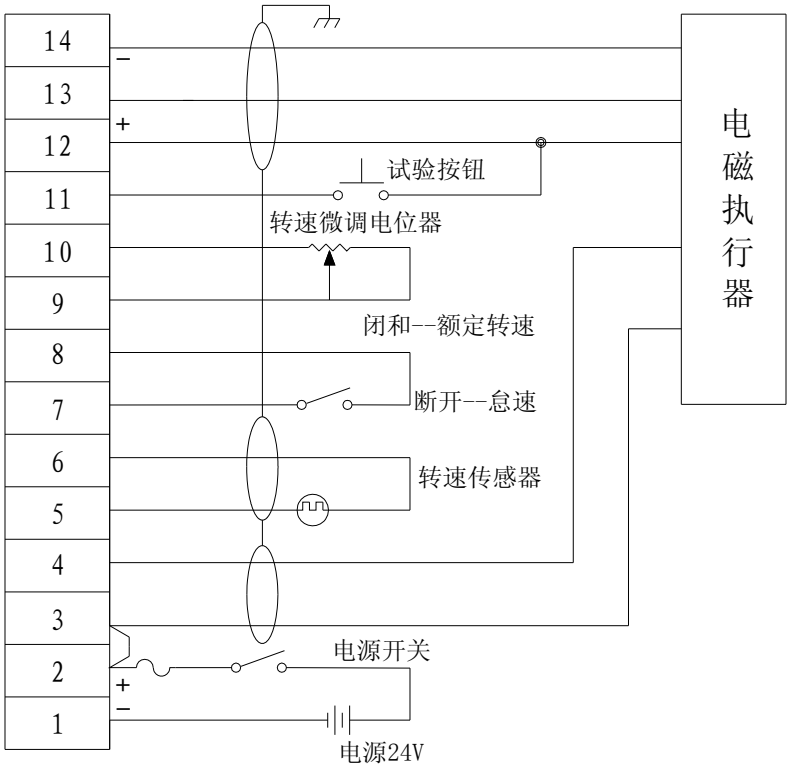


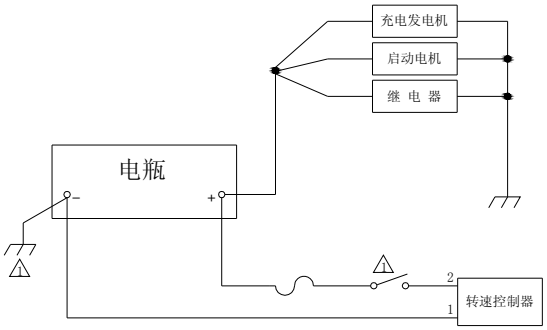
图 2.3 C1000 转速控制器接线图

2.1.5.1 接线端口的定义及外接线束的要求

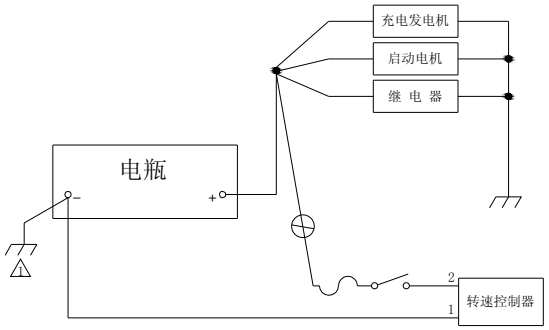
端子	线束	
	6 米以下	6 米以上
1、2 接电瓶（参考控制器电压值）	1 mm^2	2.5 mm^2
3、4 接执行器绕组端	1 mm^2	2.5 mm^2
5、6 接转速传感器（两端最低运行信号为交流 3V）	0.5 mm^2	1 mm^2
7、8 接怠速额定转换开关	各信号点均为毫安级电流，因而可使用 0.5 mm^2 ～ 1 mm^2 的线束进行连接。在有强电磁场的环境内，应使用带有屏蔽的线进行连接，屏蔽网必须有效地就近接到控制器的接地端。	
9、10 接转速微调电位器		
11、12 接试验按钮		
12、13、14 接执行器的位置反馈器（12 为正端、13 为输入信号端、14 为负端）		

2.1.5.2 电子调速系统接线时应注意的几个问题

● 1、2 端子接电瓶(BATTERY）取电，3、4 端子接执行器线圈绕组(ACTUATOR)，要求两组线截面应足够粗，线缆越长要求线径越粗。电瓶正极到转速控制器电源正极(即端子 2)之间的线缆上串接 10 A 的保险丝(FUSE)是十分必要的；如果电瓶负极需接大地，则应在电瓶负极端接大地，不得从转速控制器端（1 端）接大地，**控制器的电源线应单独、直接从电瓶的正负极取出，而不得绕道其他接口，正确接线如下：**



☑正确的电源接线图



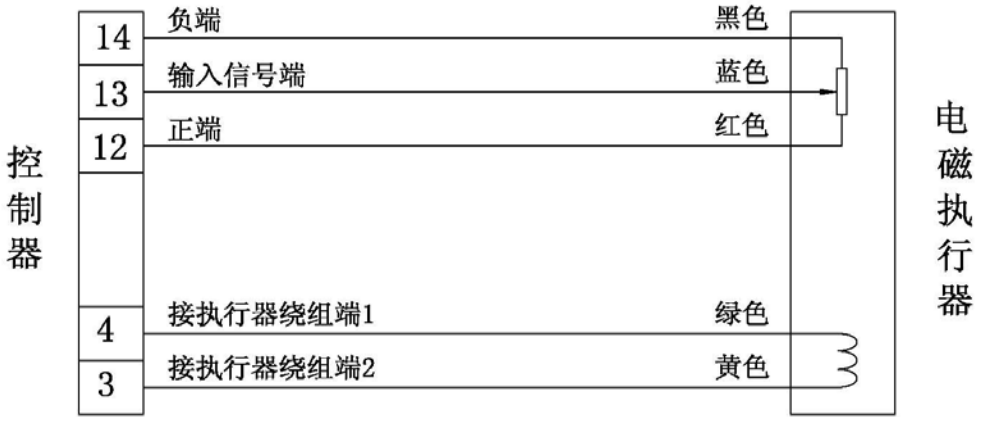
■错误的电源接线图

● 5、6 端子接转速传感器(PICK-UP)，转速传感器必须全程使用编织屏蔽网线缆连接，线缆的屏蔽网部分应 360 度环接到支点（端子 5）上，不可与发动机的其他任何地连接，否则干扰信号可能进入转速控制器，造成难以预测的后果；**电子调速系统所使用到的转速传感器必须供电子调速系统单独使用，而不得与其他测速系统共用，否则将有可能造成非常严重的后果；**

● 9、10 端子可接转速微调电位器（FREQ TRIM），用于对转速进行精细调整，如果线缆长度超过所要求的极限值，则必须使用编织屏蔽网线缆进行连接，屏蔽网应 360 度就近环接到外壳地上；**当不需使用此微调电位器时或微调电位器已经损坏，则必须将 9、10 端子使用连接线进行短接，否则发动机组将无法实现高速；**

● 11、12 接试验按钮，用于检测执行器是否正常；

● 执行器线束与各端口的关系



2.2 电磁执行器(ACTUATOR)

本说明书所述转速控制器可与我公司生产的所有双闭环电磁执行器配套使用，用户可根据油泵的型号灵活地选用我公司生产的双闭环电磁执行器及配套的中间体等，或由我公司的专业配试人员进行现场配试，为您的产品提供最佳的配机方案；本说明书所列电磁执行器是根据您产品的配机要求罗列的，若需查询我公司生产的其它类型的电磁执行器及详细资料可通过扉页联系表与我们联系；我们将竭诚为您服务，给您提供专业的解决方案。

2.2.1 A1000C-F 电磁执行器

☑ 电源电压： DC24V、DC12V 可选（订货时注明）

☑ 工作能力： 1N•m

☑ 工作行程： 22mm

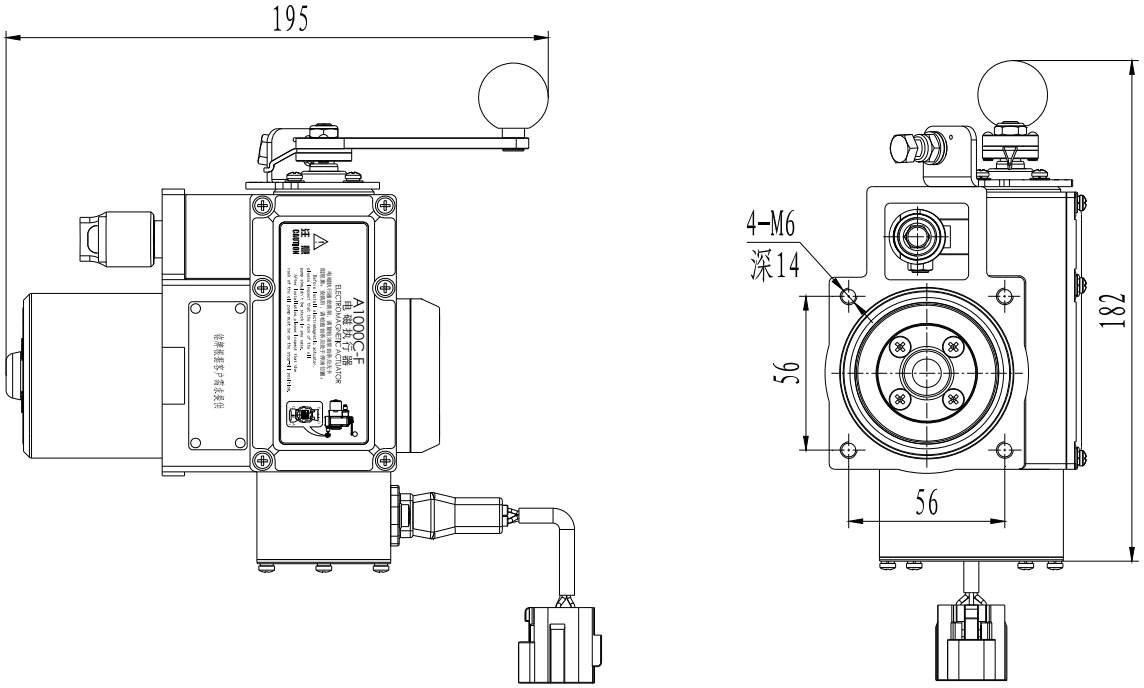


图 2.2.1 A1000C-F 电磁执行器外形及安装尺寸图

2.2.2 A2000C-F 电磁执行器

☑ 电源电压： DC24V

☑ 工作能力： 2N•m

☑ 工作行程： 22mm

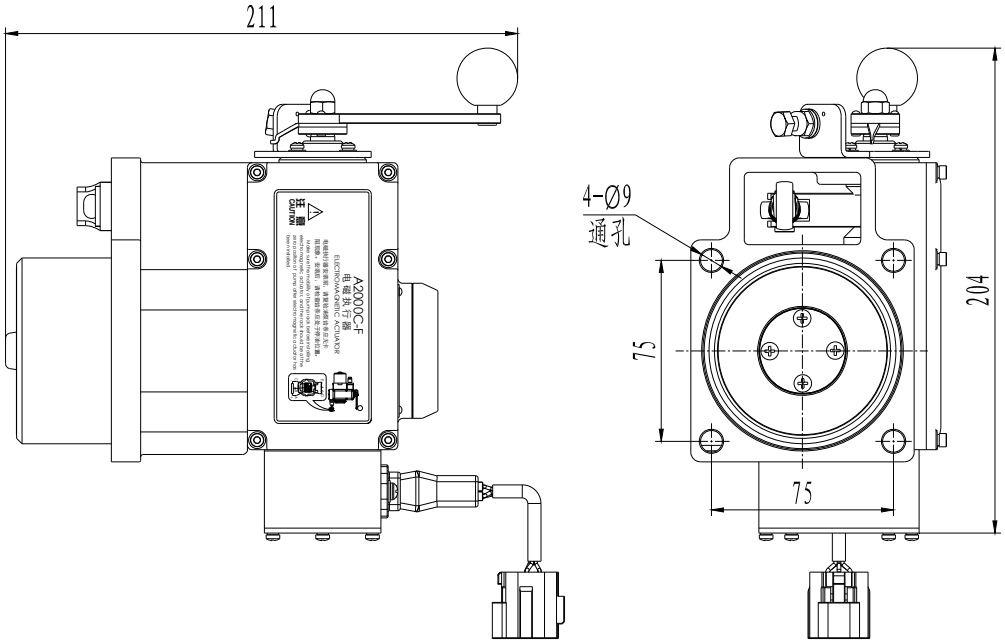


图 2.2.2 A2000C-F 电磁执行器外形及安装尺寸图

2.3 转速传感器(PICK-UP)

本电子调速系统所采用的转速传感器采用无源磁电式转速传感器，它根据测速齿轮旋转所引起的磁隙变化，在转速传感器的磁头线圈中产生出感应电动势，形成转速信号输出。转速输出信号的频率与转速的对应关系为：

$$f=nz/60$$

其中 f 为频率（Hz），n 为转速（转/分），z 为飞轮齿数（个）。

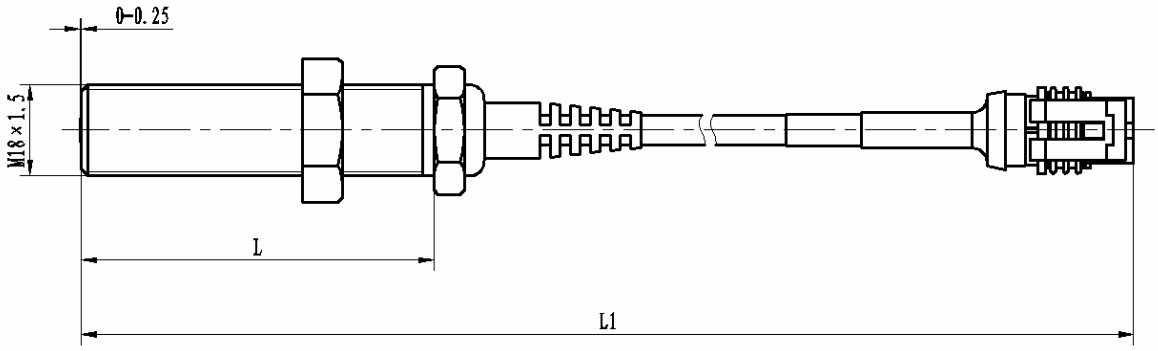


图 2.4 转速传感器外形及安装尺寸图(M16、M18、英制系列可选，本图为 M18 系列)

TM18X1.5-(L)A 系列转速传感器		
产品型号	L(MM)	L1(MM)±0.5MM
TM18X1.5-50A-00	50	315
TM18X1.5-70A-00	70	330
TM18X1.5-90A-00	90	353
TM18X1.5-130A-00	130	392

*可提供多种安装尺寸，用户可根据实际需要进行选择。

警告：本电子调速器系统中所使用到的转速传感器不得与其他测速系统共用，否则可能造成非常严重的后果！

3 安装与调试

3.1 ESG1000 电子调速系统接线图

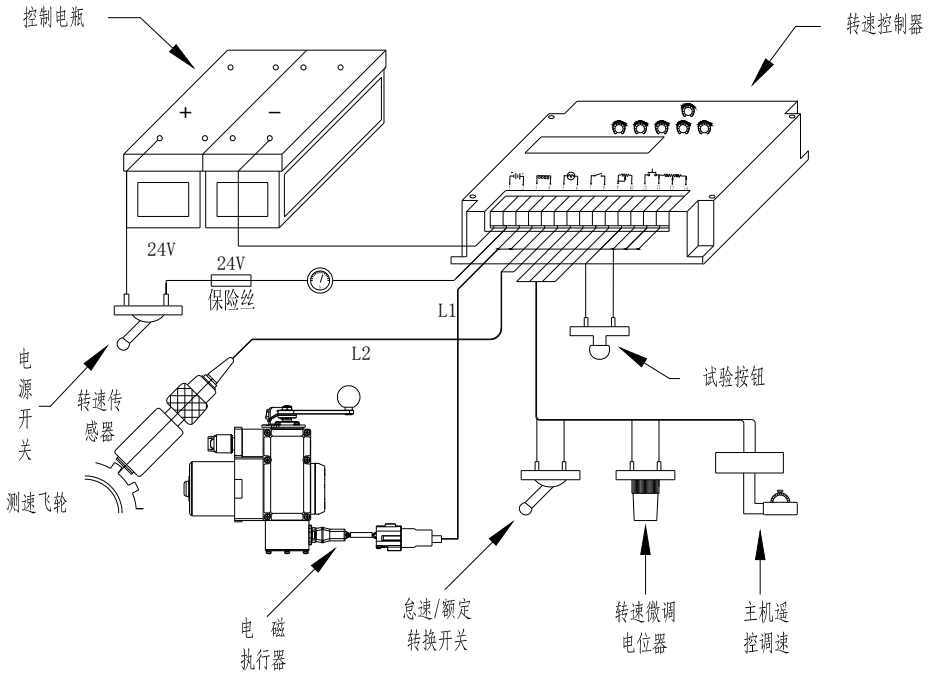


图 3.1 ESG1000 电子调速系统接线图

警告： **发动机应有独立的超速保护装置，不能依赖本电子调速系统来阻止超速.**

3.2 转速控制器的安装

C1000 转速控制器通常安装于无强烈冲击振动及电磁干扰的控制柜内，或固定在发动机其它类似场所的外围设备上，安装时应尽量选择空气干燥、温度适宜的地方安装；转速控制器有防潮处理，但仍须防止水、雾或者凝结物等与控制器接触；安装时应远离高温及热辐射，以防止控制器高温损坏；如果在水和湿气比重较大的地方使用应将控制器垂直安装;若使用环境有很大的电磁场则需有特别的屏蔽装置。

3.3 转速传感器的安装

转速传感器应安装固定在发动机齿轮盘上，通过感应飞轮齿数来判断发动机的转速；安装时转速传感器应在接触到齿轮的齿顶后外旋退出 1 / 2 － 3 / 4 圈，再锁紧螺母紧固即可，这是一个较为理想的间隙。如无飞轮齿圈，也可利用其它传感齿轮，但齿轮材质必须为导磁材料，并应保证在发动机工作转速范围内，传感器输出频率不少于 1000Hz。

3.4 电磁执行器的安装

电磁执行器安装在发动机上，其安装位置与安装方式根据具体情况确定，我公司生产的电子调速器执行机构部分推荐采用与油泵一体化安装的方式，但在特殊情况下或有特定要求时，也可采用外置式安装的方式。

电磁执行器输出轴与发动机喷油泵齿条之间直接对接，直线输出，输出行程 10-30mm。安装之后的初始位置应保证油泵能可靠断油，油泵齿条行程与电磁执行器工作行程应能良好配合，一般应保证使发动机断油至满载之间的行程为电磁执行器工作行程的 75%左右。

电磁执行器输出连杆与油泵齿条之间的连接有多种方式，必须保证安装后无卡阻或滑脱的可能，安装后应达到执行器输出连杆与油泵齿条无间隙传动的目的。**若您不能确定此点，请咨询我们，我们将为您提供解决方案，如若自行连接的方式不符合要求，有可能导致严重后果的发生。**

一体化安装的方式应注意的几个问题：

- 电磁执行器输出端与发动机喷油泵之间安装封闭的防护壳体——中间体，这样可以避免污物进入而导致电磁执行器轴承卡死或过早磨损。一体化安装方式首先应注意的问题是电磁执行器零位与油泵零位（停机断油位置）的匹配，即：当电磁执行器断电输出行程为零时，能保证油泵齿条可靠断油；
- 对强制润滑高压油泵，油泵凸轮轴应加油封，运行过程中渗漏的润滑油应通过油管导入油底壳，中间体内部不能存油；否则将会严重影响电子调速器的正常工作；
- 对非强制润滑高压油泵，中间体内部应有存油，设计油位不超过齿条位置；
- 对工作温度较高的应用环境，电磁执行器与中间体之间应涂以适量密封胶后直接安装，来改善其导热性能，而不应采用密封垫；
- 中间体应开设观查孔，在试验、调试过程中可通过观察孔观察齿条运动情况，调试完毕后盖上观察孔盖板。
- 齿条与电磁执行器连接机构连接后运行应平稳、无卡阻现象。

3.5 发动机起动前调速系统的调整

若是初次起动发动机，安装时应严格检查如下几点：

▲ 检查相关电气连接

按图 3.1 或配套电子调速器系统图的要求，检查电气连接是否正确，电瓶电压应符合使用要求（电瓶空载时略大于 24V（12V），起动瞬间不低于 18V（9V））；

▲ 检查执行器的动作是否灵活

要求执行器的连杆与供油杆之间的连接应无间隙，执行器的动作灵活，执行器在自然状态下的最小位置应能可靠断油（气），在最大限位位置应能达到最大供油（气）；

▲ 检查供油杆的灵活性

要求油泵的整个供油行程无卡滞，供油杆推拉灵活。此项检查非常重要，若供油杆不灵活，意味着可能出现控制系统失灵，造成发动机转速不稳、超速、甚至飞车等严重故障。

▲ 检查出厂参数设置

我公司生产的电调在出厂时一般都已经根据配机单或供货状态协议进行过参数设置，只需按要求核对一下即可，若在特殊情况下您无法了解到这些信息，那么按以下几点进行检查和设置时必要的：

（1）检查最大油量电位器在较大位置，一般将其设置在12 点位置；观察增益(GAIN)和稳定度（STABILITY）电位器的位置，在不确定情况下请将它们设置在12 点位置；

（2）将高/低速切换开关置于低速的一端（扭子开关为 OFF）；

（3）控制器的转速设定在出厂时已经根据用户数据进行了预设，在起动柴油机前一般无需对控制器的转速设定电位器进行调整，用户只需在起动发动机后进行更为精准的调整；若不能确定转速设置值，请将额定转速设定电位器逆时针旋转到 9 点的位置，同时观察一下怠速电位器的位置，在不确定的情况下可将怠速电位器设定在 12 点钟的位置，开机后再根据需要进行调整。

3.6 发动机起动后转速控制器的参数调整

注意：在开始进行参数设定之前，以下事项是您需要关注的。

控制器上的所有电位器都是旋转不到一圈的单圈电位器，最大有效调整角度为 270 度（见图 3.2），从时钟方向看约为从 7 点顺时针到 4 点的范围，**在进行参数调整时，切记不得超过此范围强行转动，否则将导致电位器损坏，引起发动机停机、不稳定、甚至超速等严重故障。以上电位器均为精密电子器件，调整时应使用专用工具缓慢调节，以防造成人为破坏。**

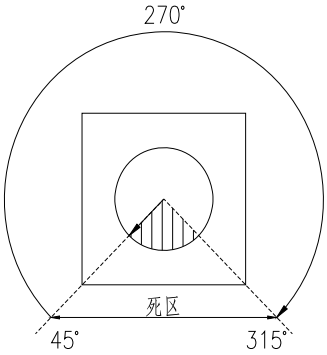


图 3.2 电位器的调节位置

3.6.1 最大油量限定

最大油量电位器是用于限定执行器的最大输出位移的，来防止用户在使用过程中超额使用发动机，给发动机带来不可预估的隐患。调整该电位器时，应先将发动机带载至最大功率负荷，然后逆时针缓慢旋转最大油量电位器，直至发动机开始掉转速为止，在此基础上再稍微顺时针回转一个小角度即可，最大油量电位器就设定完成了。

3.6.2 高低速调整

发动机起动后转速控制器应控制在怠速位（扭子开关 OFF 端），怠速电位器（IDLE）用于设定发动机在怠速工况下的转速值，顺时针方向为转速增加的方向，逆时针方向为转速降低的方向；根据开机状态下所显示的转速值，缓慢旋转怠速电位器，直到达到所要求的怠速值为止；

切换高低速开关至高速端（扭子开关 ON 端），发动机开始由怠速值根据一定的升速斜率逐渐升速到额定转速值；额定转速电位器（SPEED）用于对发动机的额定转速值进行调整，顺时针方向为转速增加的方向，逆时针方向为转速降低的方向，调整额定转速电位器直到达到所要求的额定转速值为止；

转速控制器的外接微调电位器(FREQ TRIM)可以用来遥控转速，对额定转速值进行更为精密的调整，顺时针调整时为转速增加的方向。

3.6.3 稳定性调整

电子调速器与发动机构成转速闭环控制系统，其稳定性取决于发动机转动惯量、系统时间常数、发动机环节增益、调速器环节增益、扰动等因数，调整电子调速器即调整调速器环节增益。任何闭环控制系统均具有稳定域，超出稳定域，系统就不稳定。

在稳定域示意图中（图 3.3），微分和增益在阴影区域时，表示系统稳定，小于低增益稳定线，系统将发生低频游车；大于高增益稳定线，系统将发生高频游车。在保证系统具有一定稳定余度的前提下，微分和增益应接近高增益稳定线，确保电子调速器在稳定域内工作的同时具有优良的动态调速指标。

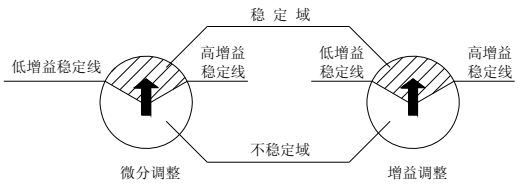


图 3.3 稳定域示意图

如果发动机起动后转速不稳定，则可阅读以下内容按步骤进行调整；稳定性的调整顺序一般为先怠速、后高速、再满载，使发动机在三种状态下都达到稳定。

注意：发动机在怠速、高速及带载情况下的稳定性是相互关联的，调整时要三者兼顾，使系统在三种工况下的稳定性都能达到最佳。在满足以上要求的情况下，增益（GAIN）电位器应尽量调节在偏大的方向，以保证发动机具有最佳的动态指标。

周期性的不稳定性又可分为快速不稳定性及慢速不稳定性。快速不稳定性一般是指频率在 3Hz 或更高频的不稳定，而频率小于 3Hz 的不稳定则称为慢速不稳定；慢速不稳定有可能是**非常强烈的不稳定，要特别小心；若出现特别强烈的慢速不稳定，应尽快调节参数将其转变为较为快速的不稳定，再进行精细的调节，以防损坏机器甚至发生事故。**

发动机的稳定性调整主要是通过对增益(GAIN)和微分(STABILITY)电位器的调整来完成。增益电位器是用来调节调速系统的灵敏度，顺时针调节是增大灵敏度，反之是减少；微分电位器是用来调节调速系统的响应时间，顺时针调节是增大响应时间的速率，反之为减少；通过对增益和微分的相互配合调节，一般可使发动机达到最佳的状态。

一般情况下，当发动机起动后，在出现不稳定状态时，可按下面步骤逐步进行调整：

1.调节增益（GAIN）电位器：顺时针旋转增益电位器，若不稳定性有增大的趋势，则逆时针旋转增益电位器直至出现稳定；若没有稳定点，则应旋转增益电位器至相对最稳定处；调节完成后应在此基础上再逆时针回调一点以确保其稳定性能；

2.调节微分（STABILITY）电位器：顺时针旋转微分电位器，若不稳定性有增大的趋势，则逆时针旋转微分电位器直至出现稳定；若没有稳定点，则应旋转微分电位器至相对最稳定处；调节完成后应在此基础上再逆时针回调一点以确保其稳定性能。

反复方案一所述的两个步骤，一般可使发动机达到所要求的稳定性。

由于控制对象——发动机的特性差异很大，在电子调速器稳定性调整时参考下述方法：

1） 对气缸数等于或小于四缸的小功率柴油机，微分置于 9 点至 11 点钟方向，将增益从 10 点钟方向开始逐渐增大至 2 点钟方向，在此范围内寻找稳定工作点。

2） 对气缸数等于或大于六缸的柴油机，微分置于 11 点至 1 点钟方向，将增益从 11 点钟方向开始逐渐增大至 3 点钟方向，在此范围内寻找稳定工作点。

3） 对气体发动机、转动惯量较大的多缸柴油机、或当负载转动惯量较大时，微分置于 12 点至 2 点钟方向，将增益从 10 点钟方向开始逐渐增大至 3 点钟方向，在此范围内寻找稳定工作点。

为检验上述调整是否达到系统的稳定工作点，应对调速系统施加扰动，视其能否迅速恢复稳定，简单的办法是：适当用力触动一下电磁执行器输出端连接器，发动机转速出现剧烈波动后应能迅速稳定。否则，应适当减小增益。

发动机额定转速调整稳定后，将发动机置于怠速，怠速时的调整方法与额定转速时相同。稳定性调整应兼顾怠速和额定转速，如不能兼顾，应优先保证额定转速的调速性能。如果怠速转速过低引起游车，适当将发动机怠速升高。

需要注意的是，以上设置及分类是根据大量的配机试验及日常使用经验而得出的结论，对于一些由于在发动机设计、制造或系统集成等方面所形成的系统的固有特性可能并不是明确地按以上分类的，甚至出现状态交叉的现象，因而说以上分类并不具有明确的对应关系。

若通过以上调整仍不能成功解决，则可能是发动机本身的问题，应检查燃油系统、进气系统及负载的稳定性，并评估发动机的性能，还应检查电源的稳定性、转速信号的幅度是否符合要求（怠速时大于 1.5Vpp，正常转速时大于 3Vpp）、转速信号线和外部调速信号线的屏蔽效果是否良好等。

3.6.4 稳态调速率的调整

稳态调速率的调整适用于多台机组并联运行；发电机组的稳态调速率通过转速控制器上的“稳态调速率”电位器调节，其顺时针方向为稳态调速率增大方向。在调节时，可将该电位器预调至一定位置，然后分别观察发动机空载与满载时的转速变化，按照图示稳态调速率计算公式，计算稳态调速率，如不符合要求，按照其趋势调整“稳态调速率”电位器，重复上述加载试验，反复数次直到满足要求为止。

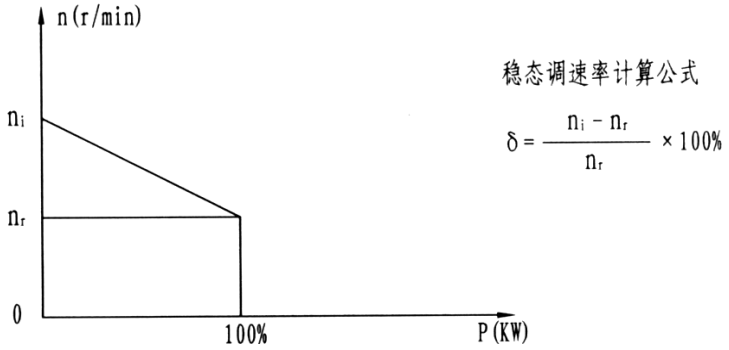


图 3.4　稳态调速率特性曲线

当您在调整稳态调速率电位器后，发动机的转速会有微小的变动，需要您重新对发动机的转速进行校正。

以下举例说明稳态调速率的调整过程：

比如现在有一台 1500 转的机组需要 3%的稳态调速率，即空载时 1545 转，满载时为 1500 转。

a.发动机起动后，在空载状态下，将稳态调速率电位器（DROOP）调至大约 12 点钟方向，然后调节额定转速电位器（SPEED）或外接微调电位器(FREQ TRIM)将发动机的转速调整为 1545 转；

b．调整完成之后，缓慢的增加负载至满载，此时发动机转速会随着负载的增加而缓慢下降；

c．记录满负载时的转速值，若满负载时转速值大于 1500 转，意味着调速率偏小，需顺时针方向调整稳态调速率电位器一点；反之说明调速率过大，需逆时针方向调整稳态调速率电位器一点；

d．注意：满负载时不得调节额定转速电位器或外接微调电位器！在经过步骤 c 的调节后，将发动机缓慢卸载至空载；

e．空载后，此时发动机的转速将不再是之前设定的 1545 转，可继续通过调节额定转速电位器或外接微调电位器将发动机的转速调整到 1545 转（此过程中不得调节稳态调速率（DROOP）电位器）；

f．不断重复 b 到 e 的步骤，直至达到发动机的速度在空载时 1545 转、满载时 1500 转便完成了所要求的 3%稳态调速率的调整。

4 故障判断与处理

4.1 电子调速器故障将引起发动机性能下降，以至于发动机不能运行；如果调速系统不起作用，且能明确判断为电子调速器故障，更换电子调速器即可；如果是发动机及其辅助系统故障，有可能通过发动机转速达不到使用要求表现出来，更换电子调速器也不能解决问题，因此，故障原因应通过对系统的综合分析,逐项验证排查来判断。

本章对以下典型故障提供了判断与处理的程序流程：

- **发动机不能起动**
- **发动机转速不稳**
- **发动机运行中自动停车**
- **发动机加载后转速急剧下跌**
- **发动机超速**

4.1.1 发动机不能起动

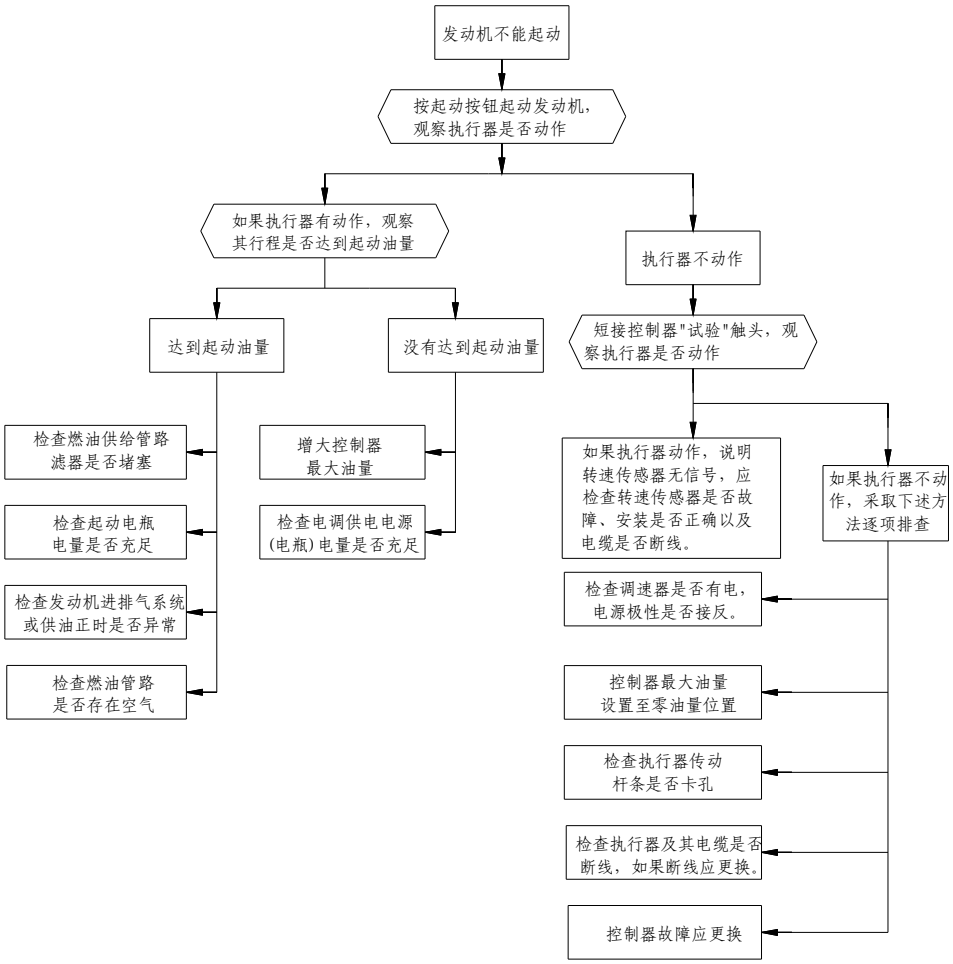


图 4.1 发动机不能起动

4.1.2 发动机转速不稳

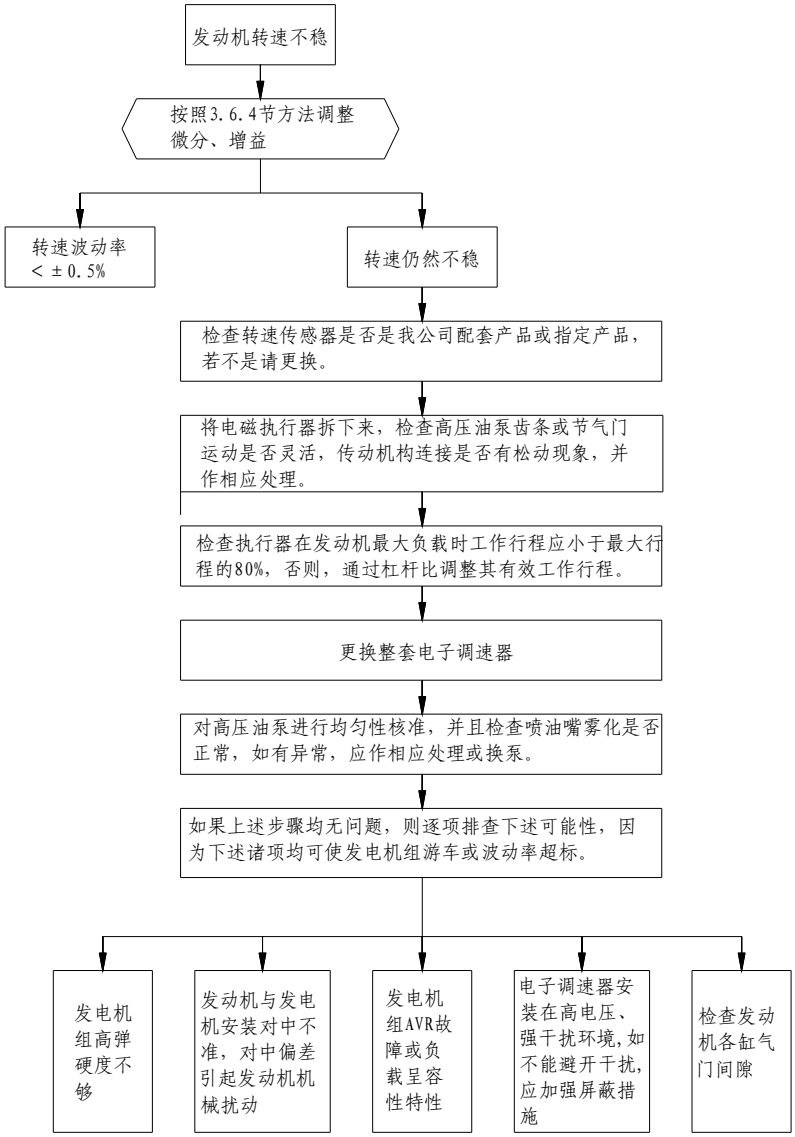


图 4.2 发动机转速不稳

4.1.3 发动机运行中自动停车

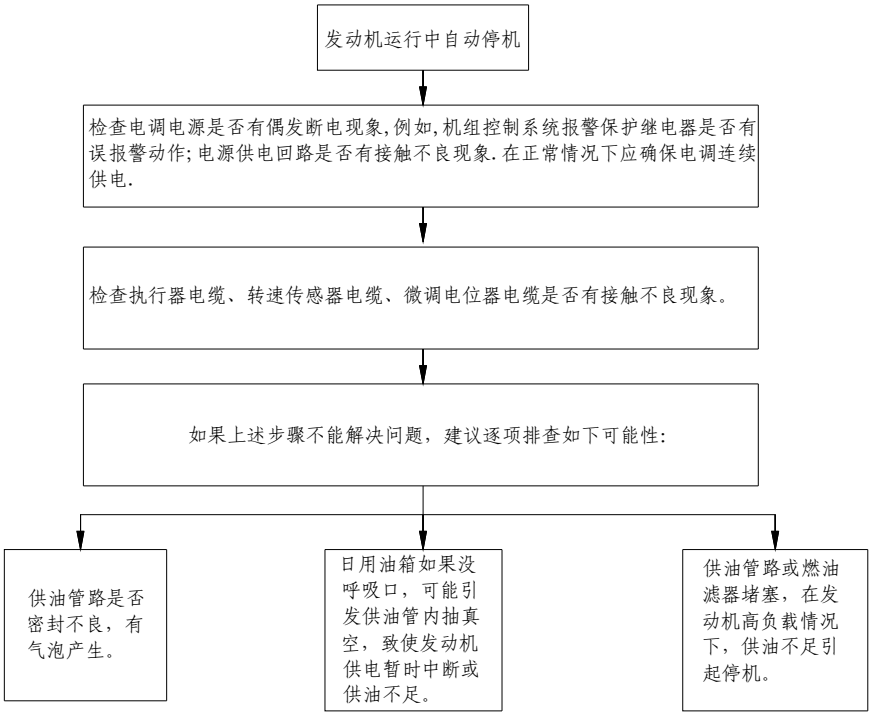


图 4.3 发动机运行中自动停车

4.1.4 发动机加载后转速急剧下降

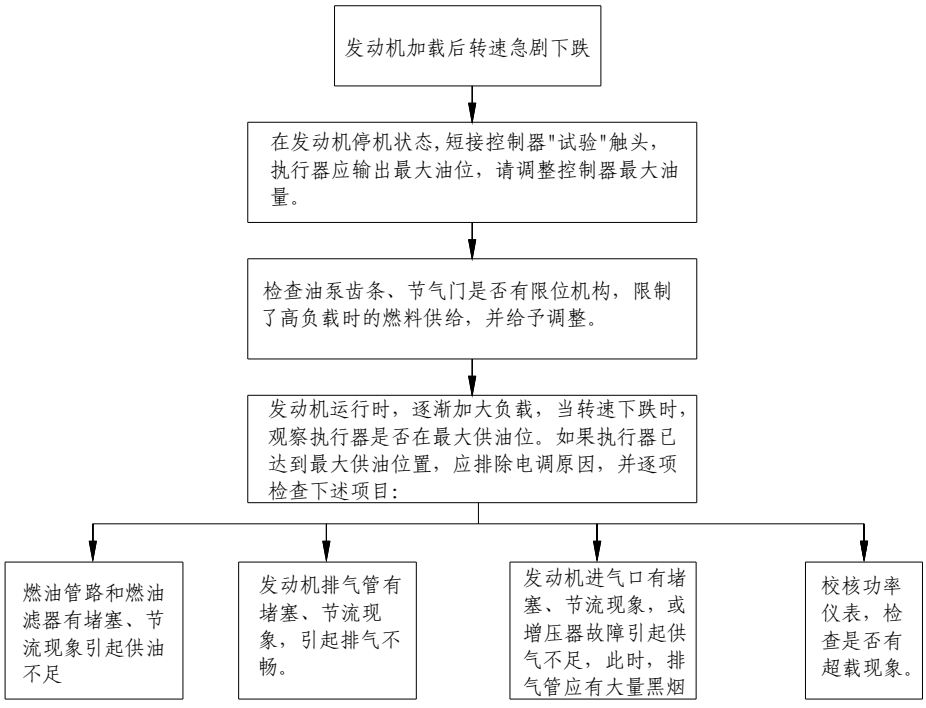


图 4.4 发动机加载后转速急剧下降

4.1.5 发动机超速

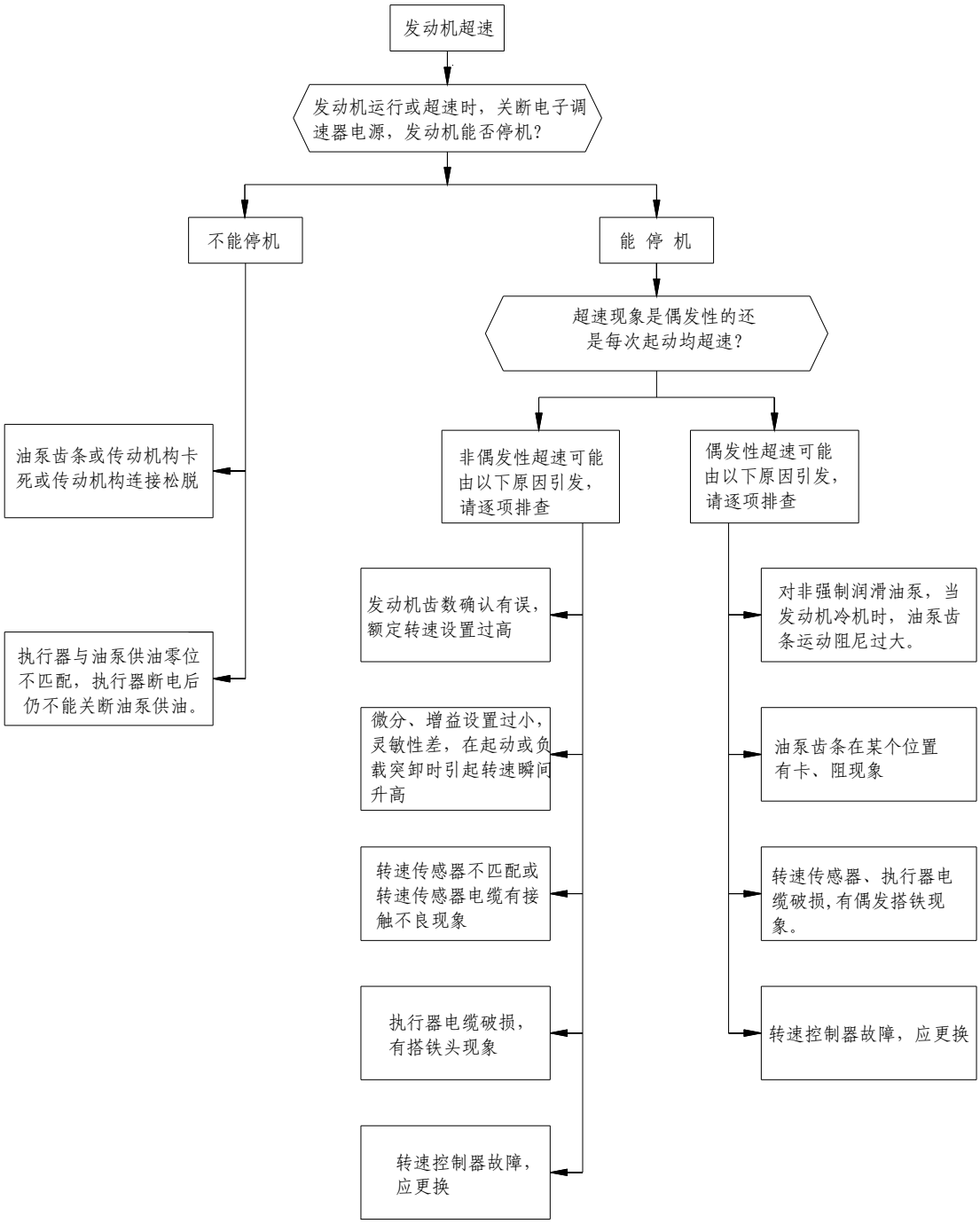


图 4.5 发动机超速

注意：若按上表检查处理后故障现象仍未排除，并确认发电机组系统无问题，则可能是调速器内部出现故障，可送交维修部门检修，请不具备维修条件的用户不要盲目拆修，以免扩大故障。

4.2 磁性不充足的速度传感器信号

当转速传感器信号较强，则能抵抗外部脉冲干扰；转速控制器能够测量到转速传感器输出 3V 以上的有效值信号。当转速信号电压低于 3V 时，应减小速度传感器和发动机的齿间隙，来提高转速信号的振幅。间隙要求在 0.45～0.8mm，如此时电压仍低于 3V，应检查转速传感器的磁性是否太弱。

4.3 电磁干扰

调速系统会被大的干扰信号通过电缆的传导或直接辐射进入到控制回路，对控制回路产生不利的偏差，给调速系统带来不良影响。为了防止中等的干扰，所有生产的转速控制器都包括过滤装置和屏蔽设置，来保护敏感回路不受外部干扰源的影响。

对干扰值的预测是复杂和困难的，对于空间场的无线电通信、无线对讲机、无线电发报机以及包括使用磁电机、固态点火系统、电压调节器或电池充电机等都应该考虑在可能的干扰源范围内。当您怀疑到空间场或其他系统在使用过程中通过传导或直接辐射的方式影响到了本调速系统的工作时，我们建议您将本控制器的所有外接线缆都使用双屏蔽线缆，并应确保屏蔽线的一端包括速度传感器的屏蔽线 360 度环接到转速控制器外壳的一个支点上，并且将速度控制器的金属板接地或安装在内封密的金属箱内，来防止电子辐射的干扰；用金属罩或金属容器效果更好；采用屏蔽线是最普通的抗干扰措施。若配用有刷的发电机，则其产生的电火花干扰是不能忽略的，所以大的干扰环境应采用特殊的屏蔽措施；若您不能解决此类问题，请与我们的工程师联系，他们将会给您提供更多的建议。

5 维护与使用注意事项

5.1 电子调速器的维护

5.1.1 日常维护

- 检查电缆是否有破损现象，并及时处理。电缆沿布置路线应捆扎紧固，避免电缆晃动与机体发生摩损；布置电缆时应避免电缆靠近高温部件（如增压器、排气管等）。
- 检查执行器安装紧固件是否松动，有松动现象应及时处理。
- 检查执行器接插件、传感器接插件以及电缆紧固螺丝是否有油污或松动，并作相应处理。
- 检查电瓶电量是否充足，充电装置工作是否正常。
- 对非强制润滑油泵，应检查高压油泵润滑油油位，并按时更换油泵润滑油。
- 在低温环境下，应先用手推动执行器摇臂数次，感觉运行平滑，无卡滞现象，再起动发动机。
- 观察执行器是否有渗油现象，如有渗油现象，应及时更换高压油泵凸轮轴油封。

5.1.2 运行 2000 小时维护

- 转速传感器探头部位可能形成积垢，应拆下清理。
- 打开中间体上的观察孔盖板，检查执行器连接器与油泵齿条的连接紧固件、销是否松动或松脱，有松动现象应及时处理。

5.1.3 运行 6000 小时维护

- 从高压油泵上拆下执行器，检查油泵齿条是否灵活。
- 在油泵校验台上检查高压油泵各缸供油均匀性以及喷油器喷油雾化情况是否正常。
- 更换转速传感器。
- 对强制润滑油泵，应更换高压油泵凸轮轴油封，以确保润滑油不向执行器侧泄漏。

5.2 使用注意事项

- 转速传感器仅供我司电子调速器独用，不能与其它测速装置共用。
- 为了确保发动机系统安全，电子调速器的调速功能不能代替超速保护功能，必须安装独立的超速保护装置。
- 每次起动发动机前，需确认“怠速/额定”转换开关处于“怠速”位置。
- 控制器各调节电位器已经出厂整定，非专业人员不得随意。
- 不能在发动机停机状态下调整（尤其是增大）转速控制器额定转速设定电位器以及转速微调电位器，避免在起动时由于转速设置过高而引起超速。
- 发动机封存较长时间后重新起用，或在低温环境起动发动机时，应先用手推动执行器摇臂（或尾轴）数次，感觉运行平滑，无卡滞现象，在有卡滞的情况下，不能起动发动机。

Preface

This manual mainly introduced the working principle, composition, adjustment, operation, maintenance and some simple fault elimination methods of the electronic speed control system. It is applicable to the staff who have knowledge of the engines and electronic speed control units and those who do some daily installment, connecting wires, using and maintenance. We suggest you shall put the manual in the workplace and strictly follow the methods provided here.

Warning

- The speed sensor of the electronic speed control system cannot be used with other systems, otherwise it will lead to serious consequences.
- You cannot completely depend on the electronic speed control system to prevent overspeed, and you shall install the independent and effective overspeed protection device on the engine system.
- You shall confirm that the oil injection rod of the pump in the cut-off position while the push-pull oil gear shall be flexible without jamming.

Contents

1 Working Principle of the Electronic Governor System

The electronic governor is the precision control device that can make the engine run in a set speed under the stable operation. The electronic governor, with its reliable performance, complete function, easy installation and maintenance and perfect speed control performance which is the unique advantages distinguished from other types of speed governors, is widely used in the fields of engine speed regulation system, monitor system of the generating set. It is becoming a development trend of the industry applications.

The electronic governor has components in respect of speed setting, speed measurement, comparison, calculation, output, executive component, parameter adjusting setting, overspeed protection or restriction. All the components form to a closed-loop control system by effective combination. (As shown in figure 1.1)

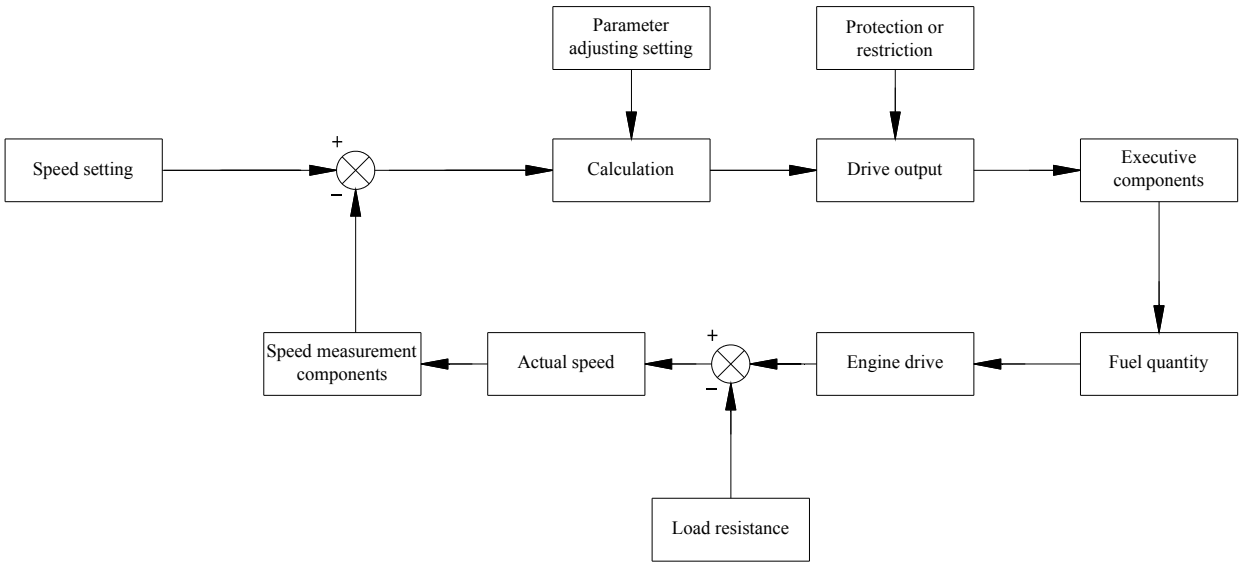


Figure 1.1 Working principle diagram of the electronic governor system

The closed-loop control mode of the electronic governor can make a quick and accurate response to the instantaneous load change, which can control the engine speed to the stable trend

Manually adjust the potentiometers such as GAIN, STABILITY and DROOP to meet the requirements of different engines on the transient adjustable rate, time stability and steady-state rate.

The electromagnetic actuator is the executive component of the governor. The speed controller can be used to control the coil current, and then it is available to control the displacement of the output.

The electromagnetic actuator directly drives the rack of the high pressure oil pump, the throttle of the gas machine, thus to control the fuel supply of the engine.

Through the thermal conversion, the engine converts the chemical energy into motion energy, output

torque, then dynamic torque and load torque interact to form the speed output of the engine.

Therefore, you can control the engine speed by controlling the current of the actuator.

The ideal speed of the engine is set by speed setting potentiometer and external trimmer potentiometer. The actual speed of the engine felt by the magnetic speed sensor installed at the tooth ring of the flywheel, the output signal is the AC voltage signal caused by frequency and engine speed.

The signal is converted into DC voltage through F/V circuit, after comparison with the speed set point, you can get the deviation value.

After calculated and amplified by PID1 regulator, the deviation value can get the engine fuel supply location value, that is the position for the steady-state output instruction of executive components; compared with the actual output of the electromagnetic actuator position, the signal can get the position deviation, after calculated and amplified by PID2 regulator, the position deviation can convert into PWM current control mode, output the drive current to the actuator to change the output displacement of the actuator, then drive the engine fuel injection pump rack or fuel control valves, throttle to reduce speed deviation in the direction of the movement so as control the speed of the engine set up under a stable operation.

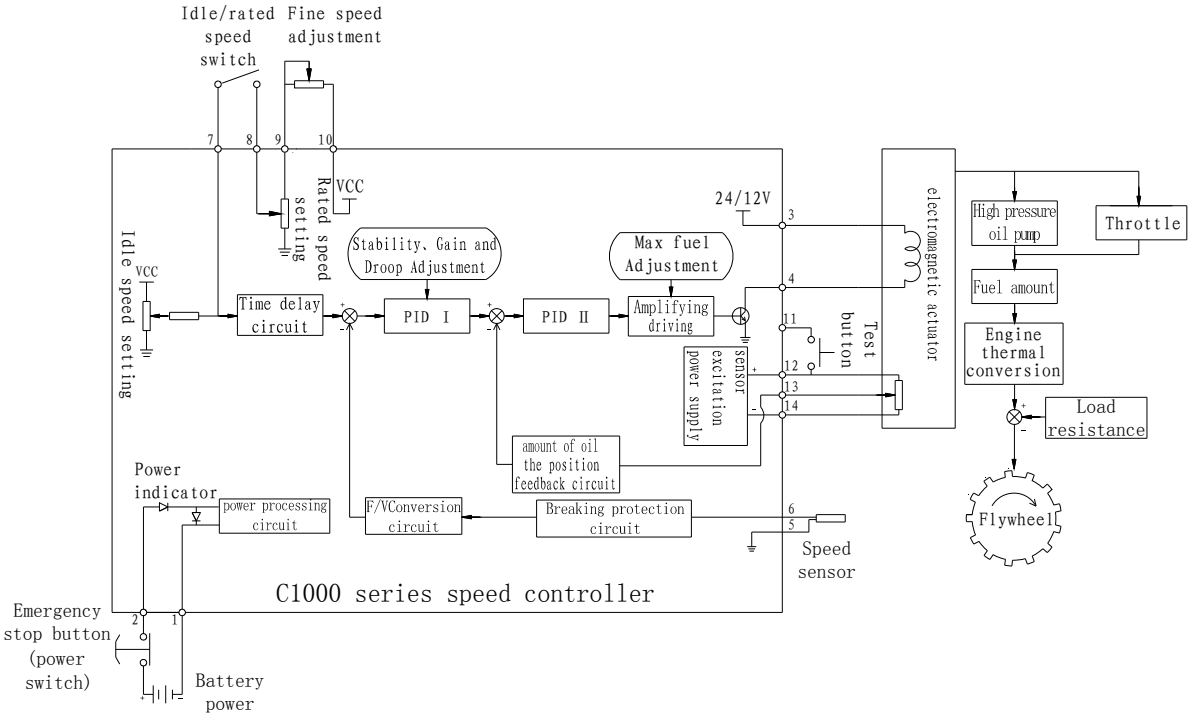


Figure 1.2 Schematic diagram for the control system of ESG1000 series electronic governor

2 Composition of the Electronic Speed Control System

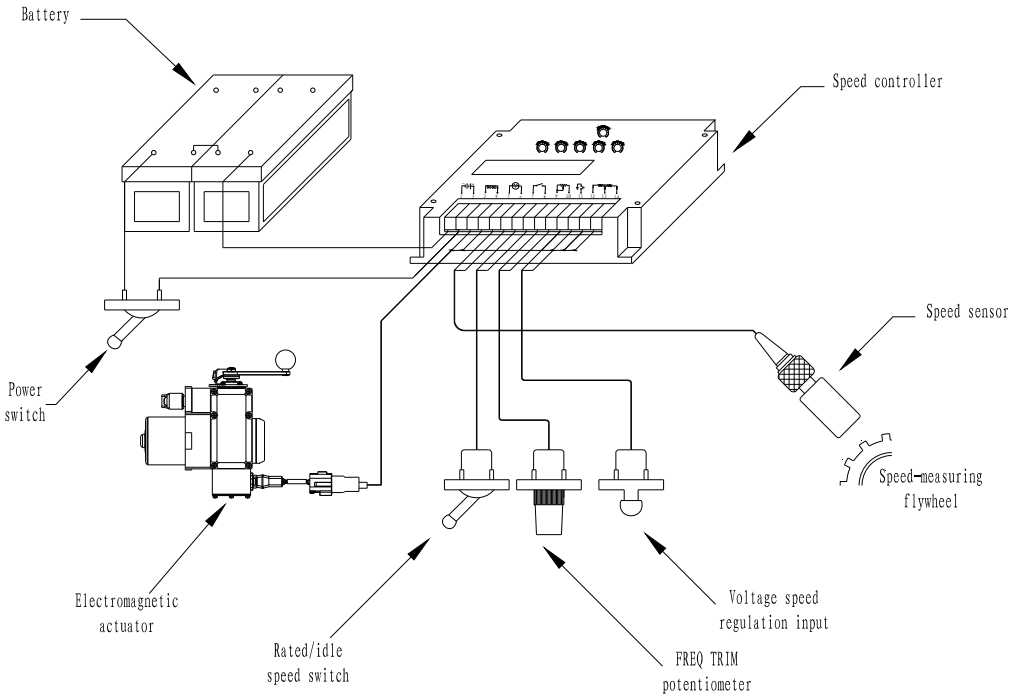


Figure 2.1 Constitutional diagram for the basic system of the ESG1000 series electronic governor

2.1 Speed controller C1000

2.1.1 The basic electronic characteristics

☑ SUPPLY VOLTAGE: DC 24V (Scope 18V～32V)

☑ SUPPLLY CONSUMPTION: < 0.1A (excluding actuator)

☑ Control frequency: 1000～13000Hz

☑ SPEED FLUCTUATION RATIO: ≤ ±0.25%

☑ STEADY- STATE SPEED DROOP: 0~5% Adjustable

☑ Transient adjustable rate: ≤ 10 %

☑ The environment temperature : -40℃～ +80℃

☑ Environmental humidity: < 95%

☑ . Protection grade: IP44

2.1.2 The basic function of the speed controller C1000

- Max fuel: limiting the max fuel injection qty. of the pump to prevent excess use of the engine;
- Speed control and fine adjustment: adopting the double closed-loop method to realize accurate speed adjustment and remote control;

- High and low speed conversion: can convert between idle status and rated status
- Droop adjustable: can adjust the speed range
- Parallel machine function: can realize parallel machine function by manual way
- The whole speed adjusting: can adjust speed in a continuous and smooth condition within a certain range
- Automatic shutdown protection: when the speed signal disappears or the controller is power off, the engine will shutdown automatically.

Please refer to the parameter setting in the subsequent chapters in details for the realization of all the above mentioned functions. According to the different requirements of different users, the whole speed adjusting function shall install different external accessories. If the user has any need, please contact with us.

2.1.3 Extending function of the speed controller C1000

In addition to the above mentioned functions, the speed controller C1000 also has some inner functions such as speed range, A/B plate and gas machine, other functions. These functions can be set by changing different jumped line positions inside the controller. The prominent characteristics of the speed controller is using the double closed-loop control circuit and speed filter capacitance redundancy design, which make it have a perfect performance and more functions, easy to install and high in reliability .

- TP1: Voltage monitoring point for speed setting: the collecting voltage is V1 which shall be equal to V2;
- TP2: Feedback speed voltage monitoring point, the collecting voltage is V2;
- J1: Control the setting of jumper wire in frequency range

  N1(1M): ≤ 1700Hz; N2(2M): ≤ 3400Hz

  N3(4M): ≤ 6800Hz; N4(8M): ≤ 13400Hz
- J2: Suitable for the A/B plate setting of feedback device in different positions
  - **a.** speed controller C1000-A
  - **b.** speed controller C1000-B
- J3: suitable for the gas machine control
  - **c.** C1000-A of C1000-B speed controller
  - **d.** special for the gas machine----speed controller C1000-Q
- J4: High speed switching time selection jumper
  - **e.** Delay increases about 3 seconds
  - **f.**Delay increases about 10seconds

Note: For the setting of jumper wire in above optional jumper wire terminal, every jumper wire terminal is only allowed for one jumper wire instead of several ones. Otherwise it will cause serious consequences. Non-professionals cannot operate.

2.1.4 The outline and installing size of the speed controller C1000 (as shown in figure 2.2)

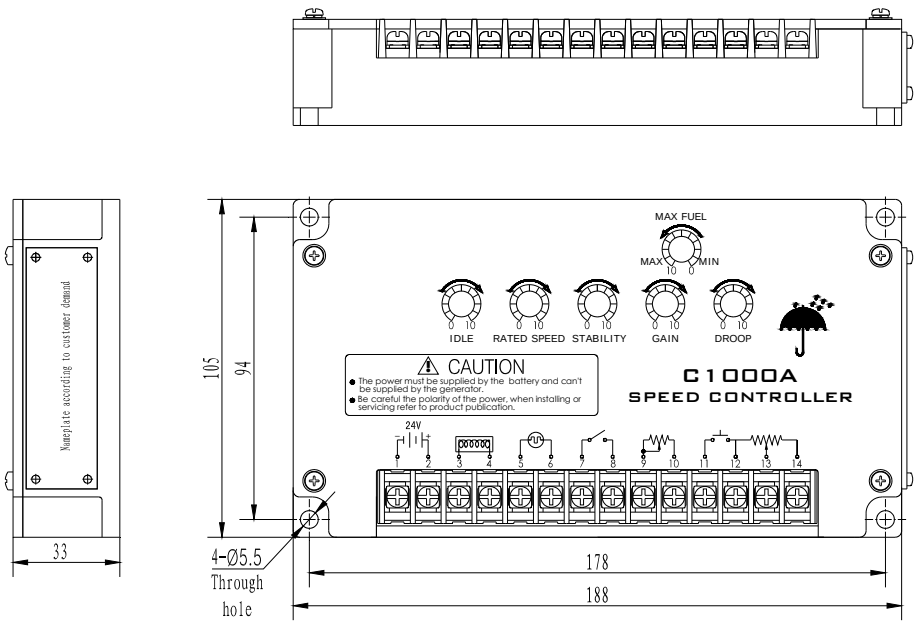


Figure 2.2.1 The outline and installing size of the speed controller C1000A

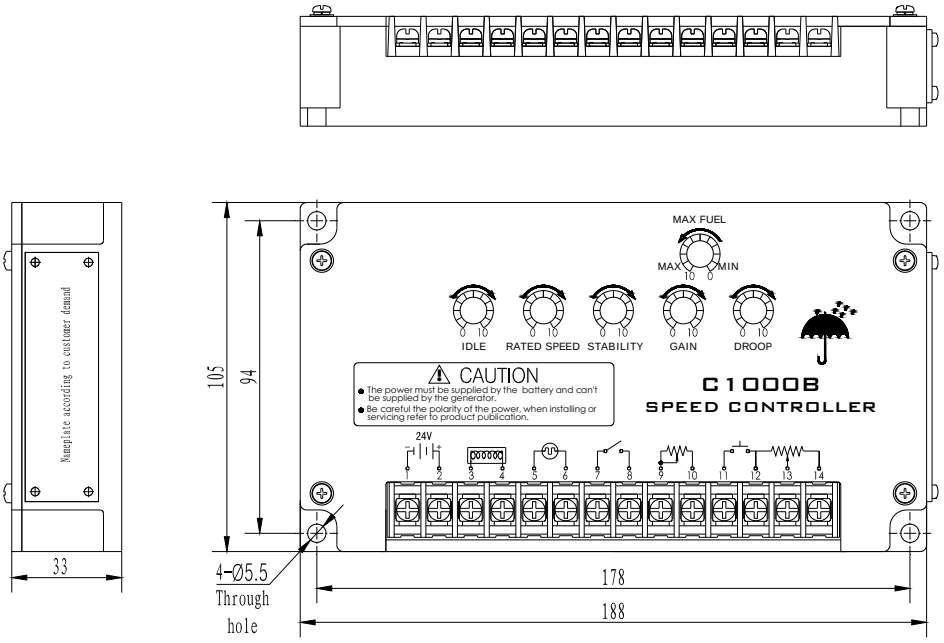


Figure 2.2.2 The outline and installing size of the speed controller C1000B

2.1.5 Connecting diagram of the speed controller C1000 (as shown in figure 2.3)

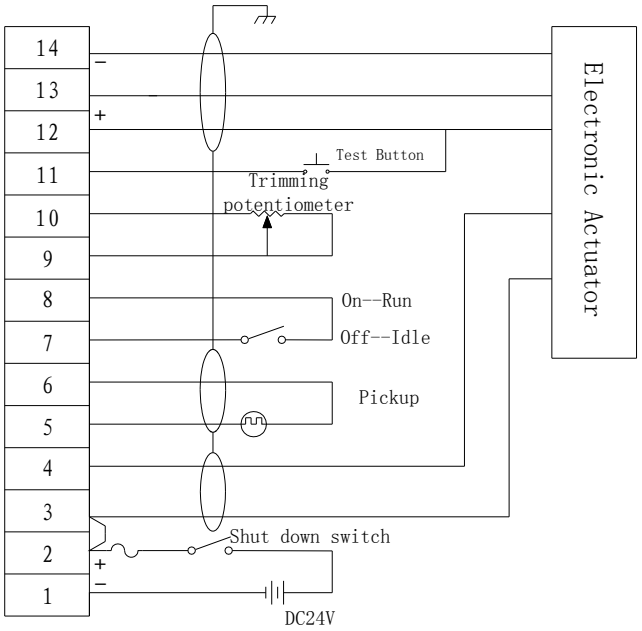


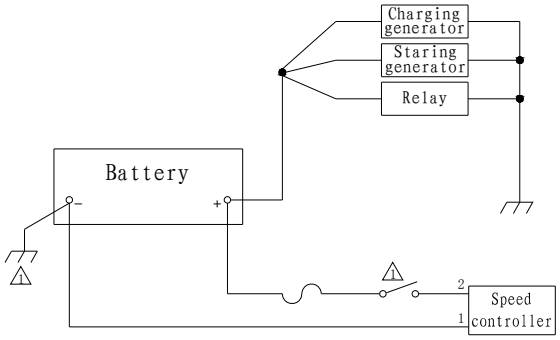
Figure 2.3 The connecting diagram of the speed controller C1000

2.1.5.1 Definition of the connecting port and requirement to the external wire harness

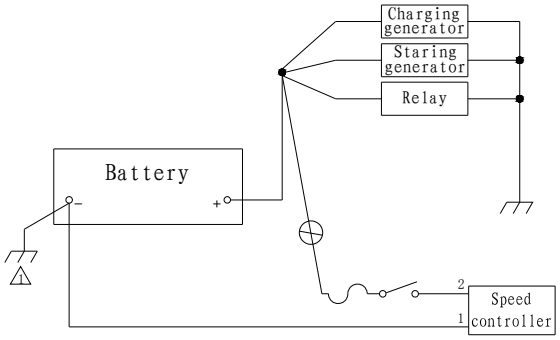
Terminal	Wire harness	
	Less than 6 meters	More than 6 meters
Terminal 1 and 2 shall connect with battery (refer to the voltage value of the controller)	1 mm^2	2.5 mm^2
Terminal 3 and 4 shall connect with the winding end of the actuator	1 mm^2	2.5 mm^2
Terminal 5 and 6 shall connect with speed sensor (the minimum signal of the both ends is AC 3V)	0.5 mm^2	1 mm^2
Terminal 7 and 8 shall connect with the idle speed rated switch	The signal points are milliampere level current, so 0.5 mm2 ~ 1 mm2 wire harness can be used for connection. In a strong magnetic field environment, you shall use the shield lines to for connection and shielding net shall connect the nearest grounded end of the controller effectively.	
Terminal 9 and 10 shall connect with FREQ TRIM potentiometer		
Terminal 11 and 12 shall Test Button		
Terminal 12, 13 and 14 shall connect with the position feedback device (12 is the positive terminal , 13 is the input signal terminal , 14 is the negative terminal)		

2.1.5.2 Several problems required to be paid attention to in the connection of electronic governor

- Terminal 1 and 2 connect with battery for electricity, Terminal 3 and 4 connect with the winding end of the actuator, requiring the two groups of line sections to be thick enough, and the longer the cables, the thicker the wire diameters shall be. It is necessary that there is a fuse of 10A serially connected on the cable between positive battery electrode and positive speed controller electrode (terminal 2); if the negative electrode of battery needs to be grounded, the grounding shall be done in the negative electrode terminal, instead of the speed controller terminal (terminal 1). The power line of the controller shall be taken out from the positive and negative electrode of the battery separately and directly, instead of bypassing other interfaces. The correct connections are as below:



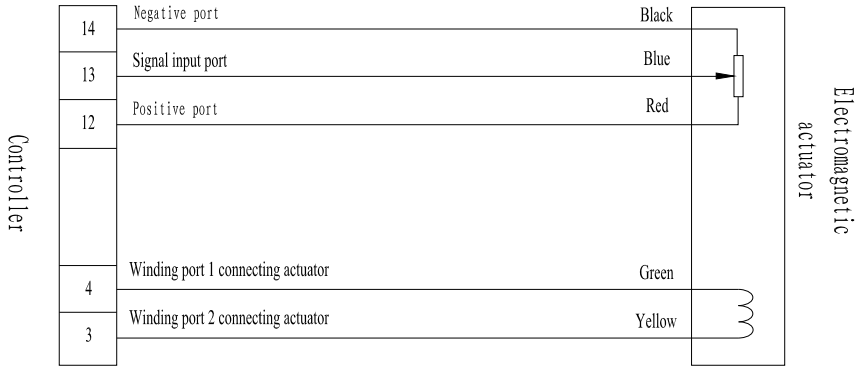
☑ The correct wiring diagram



■ The wrong wiring diagram

- Terminal 5 and 6 shall connect with the speed sensor (pick-up), it shall use the whole braided shielding net cable to connect ,the shielding net part of the cable shall be 360-degree connected to the fulcrum (terminal 5) and cannot be connected to anywhere else of the engine, otherwise the interference signal may enter into the speed controller and lead to unpredictable consequence; The speed sensor used in the electronic speed control system produced by Our company must be used by the speed control system separately and cannot be used with other speed measuring systems ,otherwise it may lead to serious consequences.
- Terminal 9 and 10 shall connect with trimmer potentiometer (FREQ TRIM) for adjustment of the speed. If the length of cable exceeds the required limited value, you must use the braid shielding network cable for connection, the shielding net ring shall be 360-degree connected to the enclosure ground; When there is no need to use the FREQ TRIM or the FREQ TRIM is out-of work, you must use the terminals 9 and 10 for short connection, otherwise the engine can't realize the high speed.
- Terminal 11 and 12 shall Test Button， for the detection of actuator is normal

- The relationship between wire harness of the actuator and various ports



2.2 Actuator

The speed controller in this manual can be used with the double closed-loop electromagnetic actuator produced by Our company. Users can select the double closed-loop actuator and intermediates produced by Our company according to the different requirements, or our professionals can match the products on the scene to provide the best solutions; the actuator in this manual is listed according to your matching requirements, If there is any enquiry to our other actuators or any further information, please contact us by the mentioned contact info：We will try our best to serve you and provide the professional solutions!

2.2.1 A1000C-F Actuator

☑ The power supply voltage： DC24V、DC12V can choose (Specify when ordering)

☑ Working ability： 1N•m

☑ Working stroke： 22mm

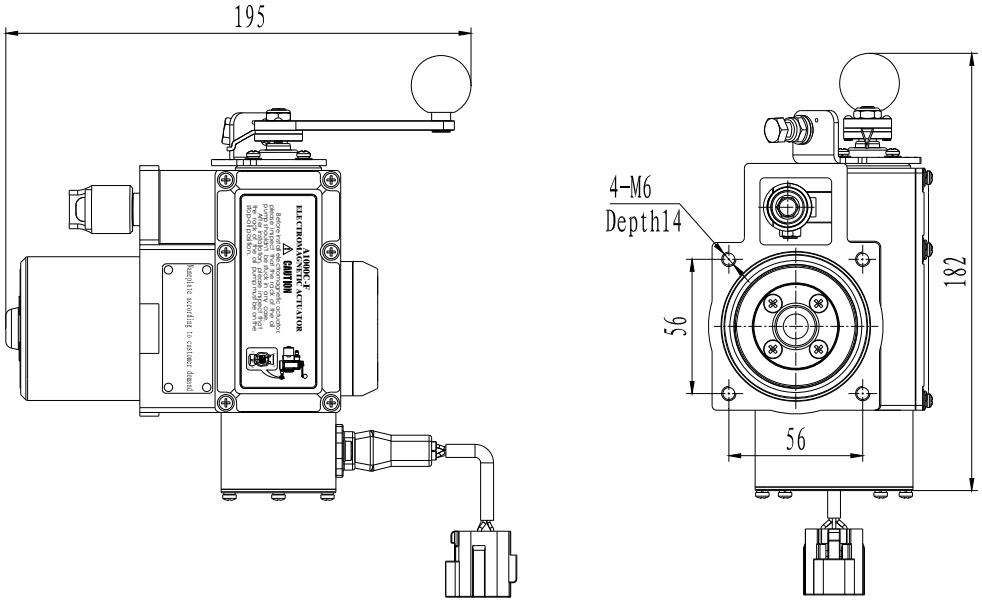


Figure 2.4 A1000C-F Actuator Shape and size of installation

2.2.2 A2000C-F Actuator

☑ The power supply voltage: DC24V

☑ Working ability: 2N•m

☑ Working stroke: 22mm

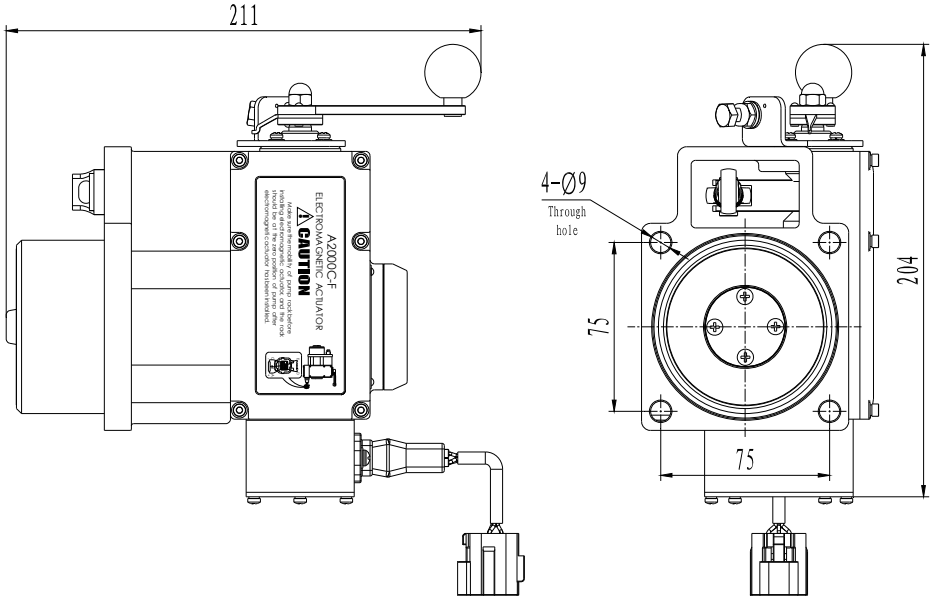


Figure 2.5 A2000C-F Actuator Shape and size of installation

2.3 Speed sensor (PICK-UP)

The speed sensor (PICK-UP) of this electronic speed control system uses the passive magnetoelectric speed sensor that changes according to magnetic gap caused by the rotation of speed measuring gear, outputing speed signal which caused by the inductive electromotive force produced by the pick-up.

The corresponding relation between the frequency and speed of the output signal is as below:

f=nz/60

In which, f is frequency (Hz), n is RPM (revolutions per minute), z is number of flywheel gears (piece).

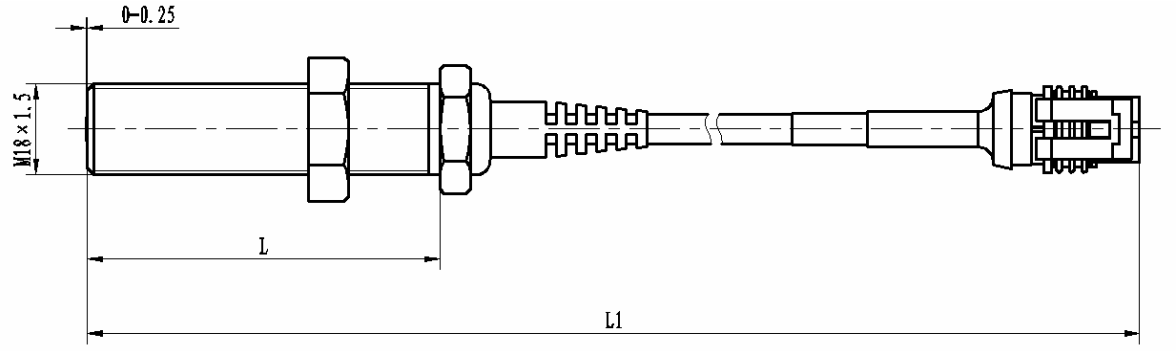


Figure 2.6 The outline and installing size of the PICK-UP (M16, M18 series can choose, this chart is M18)

TM18X1.5-(L)A series PICK-UP		
Product Model	L(MM)	L1(MM)±0.5MM
TM18X1.5-50A-00	50	315
TM18X1.5-70A-00	70	330
TM18X1.5-90A-00	90	353
TM18X1.5-130A-00	130	392

We can provide different installation sizes, so you can select according to your different requirements.

Warning: the speed sensor of the electronic speed control system shall not be used with other systems, otherwise it may cause very serious consequences!

3 Installation and Adjustment

3.1 Connection diagram of ESG1000 series electronic governor

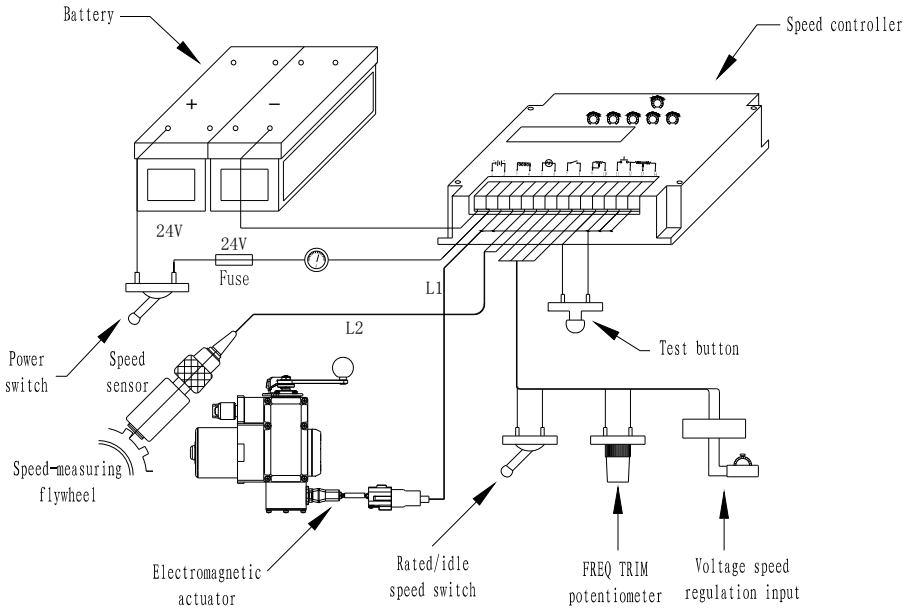


Figure 3.1 The connection diagram of ESG1000 series electronic governor

Warning: the engine shall have independent over-speed protection device, and cannot depend on this electronic speed control system to prevent overspeed.

3.2 Installation of the speed controller

The speed controller C1000 is usually installed in the control cabinet where there is no strong impact vibration and electromagnetic interference, or fixed on the outer equipments in other similar places of the engine; you shall choose the location with dry air and appropriate temperature to install; the speed controller has the moistureproof processing, but still have to prevent from water, fog or coagulation; when installation , it shall be far away from the high temperature and thermal radiation to avoid the damage of high temperature; it shall be installed vertically under the moisture condition; special shielding device shall be used under the condition with huge electromagnetic field .

3.3 Installation of the speed sensor (PICK-UP)

The speed sensor(PICK-UP) shall be installed on the gear plate of the engine to determine the engine speed by induction to the number of flywheel gears; during installing, when reaching the top of the gear, the speed sensor shall exit 1/2---3/4 circle, then fasten the nut , which is a more ideal gap. If there is no flywheel ring gears, you can also use other sensing gears which must be made of magnetic material, and ensure in the working range of the engine, the output frequency of the sensor is not less than 1000Hz.

3.4 Installation of the electromagnetic actuator

The actuator is installed in the engine, its installation location and method depend on specific circumstance, we recommend installing the actuator produced by Our company with the pump in an integration installation way, but under some special circumstances or some specific requirements, you can also use the way of external installation.

The output shaft of the actuator and the injection pump rack of the engine joint directly, with output in a straight line and the output displacement of 10-30mm.After installation, the initial position shall guarantee that the pump can have fuel cut reliably and the pump rack stroke and the actuator stroke shall cooperate well. Generally, it is required to ensure the stroke from fuel cut to fuel full to be about 75% of the actuator's working stroke.

There are several connecting ways between output connecting rod of the actuator and the pump rack, which must ensure there is no jam or slippage after installation. The installation shall realize the purpose of no clearance transmission between the output connecting rod and pump rack.

If you are not sure, please consult us, we will provide you with solutions; If the connection way made by yourself fails to meet the requirements, serious consequences may be caused.

Several problems shall be paid attention to in integration installation

- You shall install closed protective enclosure -- intermediate between output terminal of the electromagnetic actuator and the fuel injection pump of the engine, so that you can avoid the dirt's entrance which will make the actuator bearing jammed or premature worn. The first problem for the integration installation you shall pay attention to is that the zero position of the actuator shall match with the zero position(shutdown and fuel cut position) of the pump, that is when the output stroke of the actuator is zero, the oil pump rack can have fuel cut reliably.
- For the forced lubrication of high pressure oil pump, the camshaft of the oil pump shall have oil seal. During operation, the leakage of the lubricating oil shall go through the tube to the oil pan, there can't have trapped oil in the internal of intermediate; otherwise it will affect the normal work of the electronic governor seriously.
- For the high pressure oil pump of unforced lubrication, there shall be trapped oil in the intermediate, the designed oil level shall not exceed the rack position.
- For the work environment with high temperature, the electromagnetic actuator and intermediate shall be coated with a suitable amount of sealant instead of seal packing, and then installed directly to improve its thermal performance.
- There shall be an observation hole in the intermediate, you can observe the movement situation of the rack

during the period of testing and debugging, and after debugging, you shall cover the observation hole with the cover plate.

- After the rack is connected with the connecting mechanism of the actuator, the operation shall be smooth with no jam phenomenon.

3.5 Adjusting of the speed control system before the engine starts

If this is the first time to start the engine, please check the following points strictly when installation.

▲ **Check the related electrical connections**

According to the figure 3.1 or the requirements of the electronic governor system diagram, check whether the electrical connection is correct, the battery voltage shall conform to the using requirements (in the situation of no-load, the battery shall be slightly large than 24V (12V); in the situation of the starting moment, the battery shall not be less than 18V (9V);

▲ **Check whether actions of the actuator are flexible**

It is required that there is no space between the connecting rod and oil rod of the actuator, the action of the actuator shall be flexible. In the natural state, the actuator shall be able to break the fuel / gas in the minimum position; the actuator shall be able to achieve the maximum the oil / gas in the maximum limited position.

▲ **Check the flexibility of the oil rod**

It is required that the whole pump delivery stroke is free from binding and the oil rod works smoothly. This examination is very important .If the oil rod is not flexible, the control system maybe out-of work, which may lead to some serious consequences such as engine speed instability, over-speeding, or even engine racing.

▲ **Check the parameter setting**

In general, the governors produce by Our company are set parameters according to the requirements before delivery, so you just need to check. Under special circumstances if you can't get these information, it is necessary to check and set according to the following points;

1) please check whether the max fuel potentiometer is in the larger position, usually set at 12 o'clock position; please check the position of the GAIN potentiometer and STABILITY potentiometer, in the uncertain case, please set them at 12 o'clock position.
2) Please set the high/low speed switch in the low speed (the Toggle Switch is OFF).
3) The speed of the controller has been preset according to the user's data before delivery. In general,

you needn't to adjust the speed potentiometer before the engine starts. Users just need to do some more precise adjustments after the engine starts; if you can't ensure the set value of speed, please set the rated speed potentiometer counterclockwise to the 9 o'clock position, in the meanwhile, you shall observe the position of the IDLE potentiometer, in the uncertain case, please set the IDLE potentiometer at 12 o'clock position, and then adjust according to the different requirements after the engine starts up.

3.6 Adjustment of the speed controller parameters when the engine starts

Note: before set the parameters, you shall pay attention to the following matters.
All the potentiometers on the controller are single-loop potentiometer which revolve less than one loop, the maximum effective adjusting angle is 270 degree (see figure 3.2). When adjusting parameters, remember not to make the forced rotation exceeding the scope from 7 am to 4pm in the clockwise direction, otherwise it will lead to serious consequences such as damage of the potentiometer, engine shutoff, unstability or even over-speed. All the above potentiometers are all precise electronic device; you shall use special tools to adjust them slowly so as to avoid man-made damage.

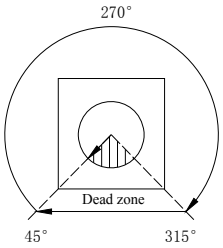


Figure 3.2 The adjusting position of the potentiometer

3.6.1 The max fuel limit

The max fuel potentiometer is used to limit the maximum output displacement of the actuator and prevent users' excess use of the engine for avoidance of unexpected hidden dangers. When adjusting the potentiometer, you shall make the engine load reach the maximum power load, then slowly rotate the max fuel potentiometer counterclockwise until the engine; speed begins to decrease. On this basis, please rotate a small angle clockwise to complete the set of the max fuel potentiometer.

3.6.2 Adjusting the high and low speed

After the engine starts, the speed controller shall in the IDLE position (OFF position of the Toggle switch), the IDLE potentiometer is used to set the speed value when the engine in the idle condition. The clockwise direction is for speed increasing and the counterclockwise direction is for speed reducing; according to the speed value when the engine starts, you shall slowly rotate the IDLE potentiometer until it reaches the required

idle value.

Switch-over the high / low speed switch to the high speed (ON position of the Toggle switch), the engine starts from the idle value to the rated speed value according to the certain speed ACC slope gradually; the SPEED potentiometer is used to adjust the rated value of the engine; the clockwise direction is for speed increasing and the counterclockwise direction is for speed reducing. You can adjust the rated SPEED potentiometer until it reaches the required rated speed value.

You can use the FERQ TRIM potentiometer of the speed controller for remote control of speed and more precise adjustment of rated speed value, with the clockwise direction as speed increasing direction.

3.6.3 Adjusting the stability

The closed-loop speed control system consists of the electronic governor and the engine. The stability depends on the moment of the inertia of the engine, system time constant, the engine link gain, the governor gain, disturbance factors and etc. The effect of adjusting the electronic governor is same as adjusting the speed governor gain. Any closed-loop control system has the stability domain and will become unstable beyond the stability domain.

In the stability domain diagram (figure 3.3), when the Stability and Gain are in the shaded area, the system is stable, when they are lower than the low gain stable line, the system will have low frequency block. When they are higher than the high gain stable line, the system will have high frequency block. While the system is guaranteed certain redundancy of stability, the Stability and Gain shall be close to the high gain stable line to ensure the governor working in the stability domain and has excellent dynamic speed indicator.

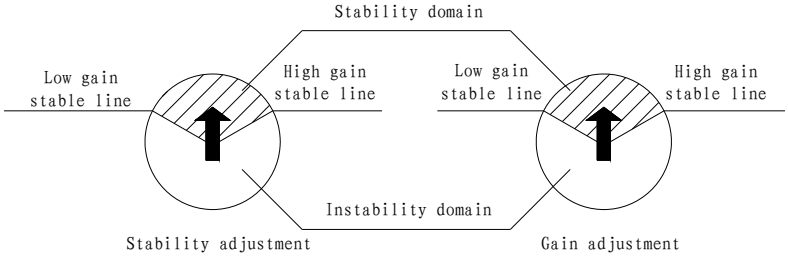


Figure 3.3 stability domain diagram

If the speed is unstable after the engine starting, you can read the following content and then adjust according the following steps; the adjusting order of the stability shall be successively idle, high speed, full-load, and make the engine achieve stability under these three statuses.

Note: the stability of the engine under idle status, high speed status and full-load status is interlinked. You shall consider the three statuses when you adjust and make the system achieve the best effect under these three statuses. When the above requirements are met, the GAIN potentiometer shall be adjusted in the larger direction to ensure that the engine has the best dynamic index.

The periodic instability can be divided into fast instability and slow instability. The fast instability generally refers to the instability in 3Hz or higher frequency and the slow instability refers to the instability in frequency less than 3Hz; the slow instability maybe strongly instable, you shall pay special attention to it; if the special instability occurs, you shall adjust the potentiometer as soon as possible to change it into the faster instability and then make a careful adjustment to avoid the damage of the machine or even the accident.

The stability adjustment of the engine is mainly done by adjusting the GAIN potentiometer and the STABILITY potentiometer. The GAIN potentiometer is used to adjust the sensitivity of the speed control system, the clockwise adjustment is to increase the sensitivity or reduce the sensitivity on the contrary; the GAIN potentiometer is used to adjust the response time of the speed control system, the clockwise adjustment is to increase the rate of the response time or reduce the rate of the response time on the contrary; through the interaction of the GAIN and STABILITY potentiometers, in general, you can make the engine achieve the perfect status.

In general, when the engine starts, you can adjust according the following steps if the instable status occurs

1. **Adjust the GAIN potentiometer** If instability has an increasing tendency when you rotate the GAIN potentiometer in the clockwise direction, you shall rotate it in the counterclockwise direction until the GAIN potentiometer in a stable status; if there is no stable point, you shall rotate the GAIN potentiometer to the relative point; based on this adjustment, you shall callback a little in the counterclockwise direction to ensure its stability;
2. **Adjust the STABILITY potentiometer** If instability has an increasing tendency when you rotate the STABILITY potentiometer in the clockwise direction, you shall rotate it in the counterclockwise direction until the STABILITY potentiometer in a stable status; if there is no stable point, you shall rotate the STABILITY potentiometer to the relative point; based on this adjustment, you shall callback a little in the counterclockwise direction to ensure its stability;

In general, when you repeat the above mentioned steps, the engine can achieve the required stability.

Due to the control object has a various characters, you can refer to the following methods to adjust the stability of the electronic governor.

1) For the small single cylinder diesel engine with number of cylinders <= 4, you shall set the STABILITY potentiometer at the direction from 9 o'clock to 11 o'clock and set the GAIN potentiometer at the direction from 10 o'clock to 2 o'clock to search the stable working point within the scope.
2) For the diesel engine with number of cylinders >= 6, you shall set the STABILITY potentiometer at the direction from11 o'clock to 1 o'clock and set the GAIN potentiometer at the direction from 11 o'clock to 3 o'clock to search the stable working point within the scope.
3) For the gas engine and multi-cylinder diesel engine with a large moment of inertia or when the load moment of inertia is larger, you shall set the STABILITY potentiometer at the direction from 12 o'clock to 2 o'clock and set the GAIN potentiometer at the direction from 10 o'clock to 3 o'clock to search the stable working point within the scope.

To test whether the above adjustment achieves the stable working point of the system, you shall exert disturbance to the system to check whether it can quickly restore stability. The simple solution is to appropriately touch the output connector of the electromagnetic actuator and the engine speed shall be quickly stable after the sharp fluctuation, otherwise, you shall decrease the GAIN.

After adjusting the rated speed of the engine, please set the engine in the IDLE status. The adjusting method in the IDLE status is same as that in rated speed. The stability adjusting shall consider both IDLE and Rated speed. If not, you shall ensure the rated speed performance in priority. If the idle speed is too low and causes the traveling block, you shall raise the idle speed of the engine.

It is important to note that the above setting and classification are based on a large number of matching tests and conclusions from daily use experience. The inherent characteristics based on the engine design, manufacturing and system integration are not classified precisely according to above classifications, even with the state cross phenomenon, thus the above classification does not have a definite corresponding relationship.

If you can't solve the problem through the above adjustment, it maybe the engine problem. You shall check the stability of the fuel system, intake system and the overload, and evaluate the performance of the engine, also you shall check whether the stability of the power supply and the amplitude of the speed signal can meet the requirement (>1.5Vpp when in idle status, >3Vpp when in normal speed) and whether the shielding effect of the rotational speed signal and the external control signal are in good condition, etc.

3.6.4 Adjusting the DROOP

The adjustment of the DROOP potentiometer is used in many sets of the parallel operation; the steady-state adjustable rate of the generator can be adjusted through the DROOP potentiometer, the clockwise direction is for increase. You can preset the potentiometer to a certain position, and then observe the speed change when the engine in the no-load status and over-load status, calculate the steady-state adjustable rate according to the calculation formula as shown; if it doesn't meet the requirement, you shall adjust the DROOP potentiometer according to its trendency, repeat the above loading test for several times until meeting the requirements.

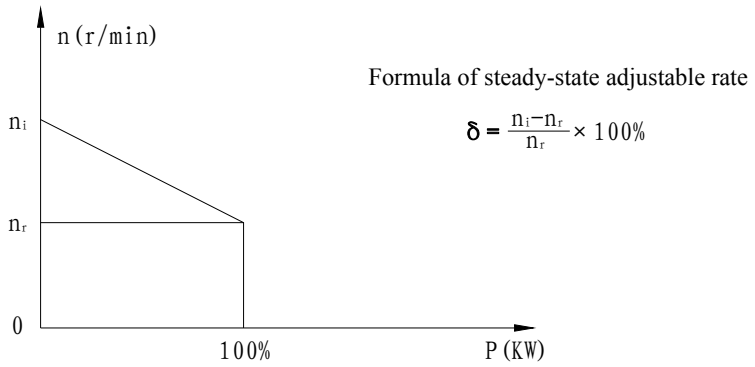


Figure 3.4 Curve of steady-state adjustable rate

When you adjust the DROOP potentiometer, the speed of the engine will have a tiny change and you shall revise the speed of the engine.

The following example will explain the process of adjusting the steady-state adjustable rate.

For example, a engine of 1500RMP needs 3% steady-state adjustable rate, this is to say, when in the no-load status, it is 1545 RMP; when in the full-load status, it is 1500 RMP.

a. After the engine starts , in the no-load status, you shall adjust the DROOP potentiometer to about the 12 o'clock direction, then adjust the SPEED potentiometer or the FREQ TRIM potentiometer, adjust the speed of the engine to 1545 RMP;

b. After the adjustment, slowly increase load to full-load status, at this time, the speed of the engine will slowly decrease with the load adding

c. Record the speed value in the full-load status. When the speed value >1500RMP in the full –load status, the steady-state adjustable rate is smaller, and you shall adjust the SPEED potentiometer in the clockwise direction; on the other hand, the steady-state adjustable rate is larger, and you shall adjust the SPEED potentiometer in the counterclockwise direction;

d. Note: you can't adjust the SPEED potentiometer or the FREQ TRIM potentiometer in the full-load status!

After the step C, unload the engine to no-load.

e. In no-load status, the rotate speed won't be 1545 RMP as set before. You shall continue to adjust the SPEED potentiometer or the FREQ TRIM potentiometer to make the speed to be 1545RMP (You can't adjust the DROOP potentiometer during this period.)

f. Continuously repeat step b to step e until the speed of the engine achieve 1545 RMP in the no-load status and 1500 RMP in the full-load status. That is to say you finish the adjustment of the required 3% steady-state adjustable rate.

4 Fault Judgment and Processing

4.1 Judgment and Processing

The fault of the electronic governor will cause the engine performance degradation which may lead the engine to shut down. If the speed regulation system is out of work and you can judge the fault of the electronic governor, you just shall change the electronic governor; Faults of engine and the auxiliary system may be indicated by that the engine speed fails to reach the using requirements, and can't be solved even if you change the electronic governor. Thus, you shall judge the caused through comprehensive analysis on system.

This chapter provides the program flows of typical fault judgment and processing:

- Engine can not start
- Engine speed instability
- Engine shuts down automatically during the running period
- Engine speed decreases sharply after loading
- Engine overspeed

4.1.1 Engine can not start

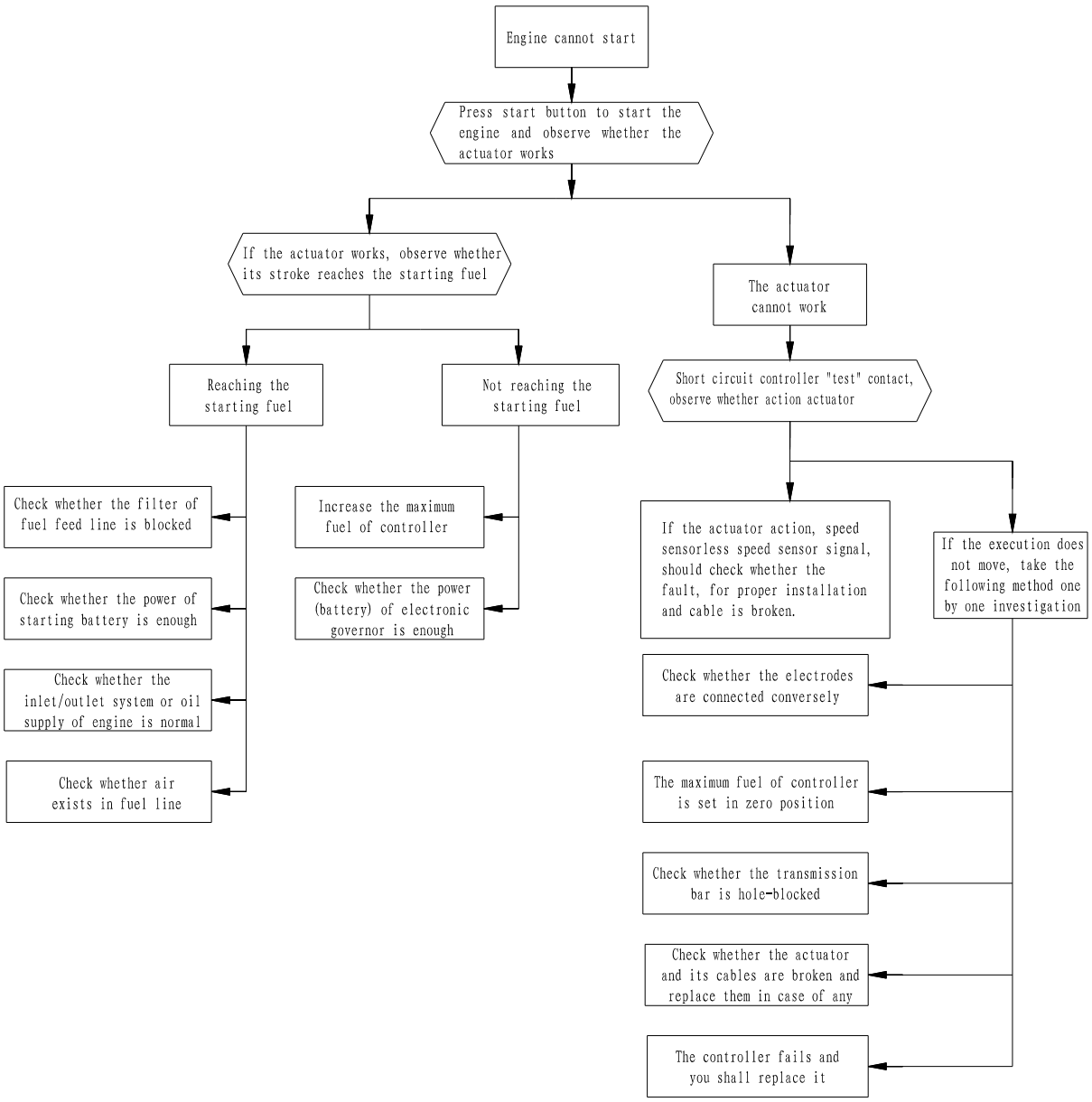


Figure 4.1 Engine cannot start

4.1.2 Engine speed instability

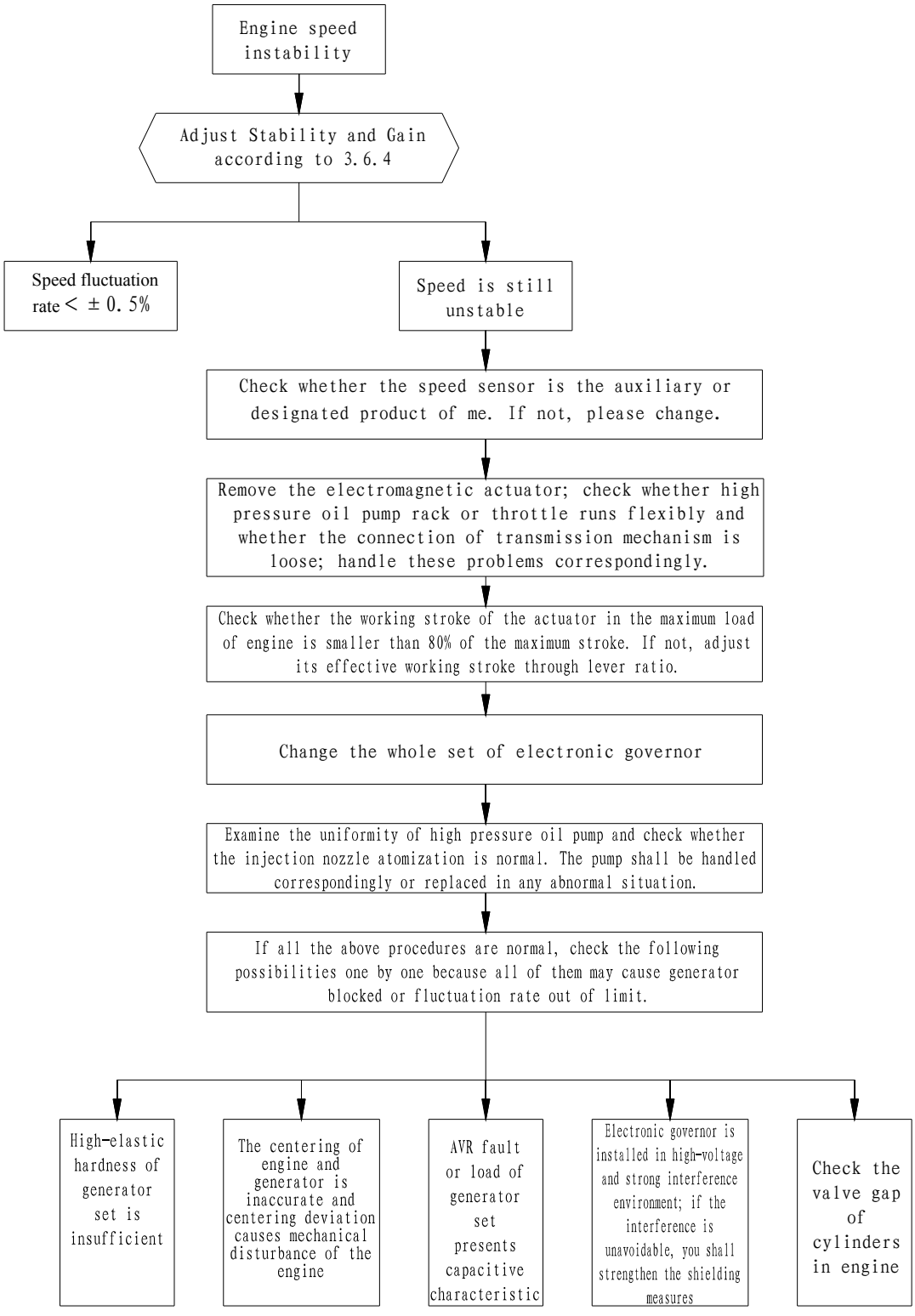


Figure 4.2 Engine speed instability

4.1.3 Engine shuts down automatically during the running period

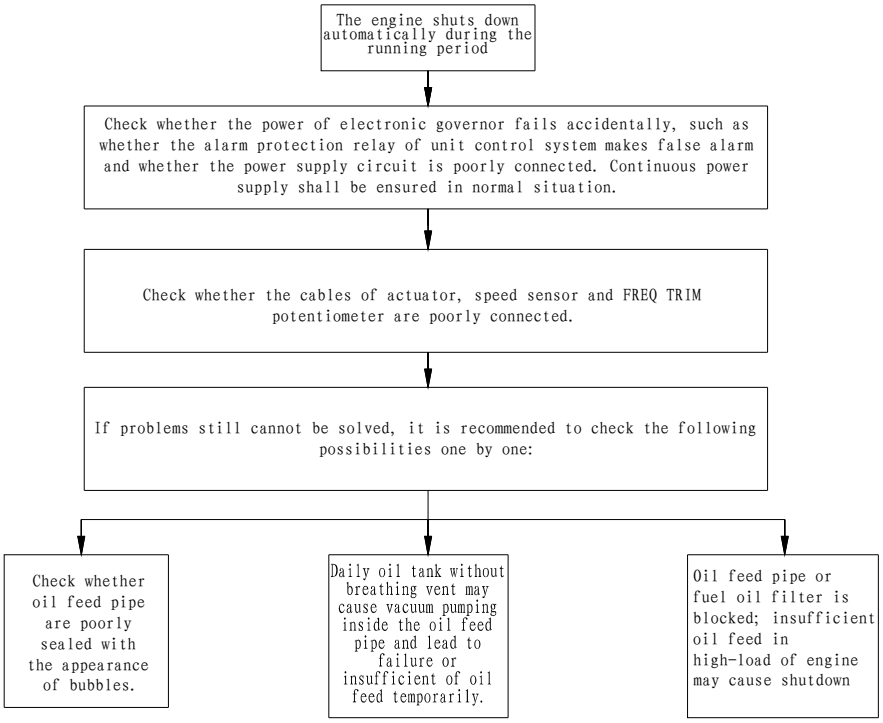


Figure 4.3 Engine shuts down during the running period

4.1.4 Engine speed fell sharply after loading

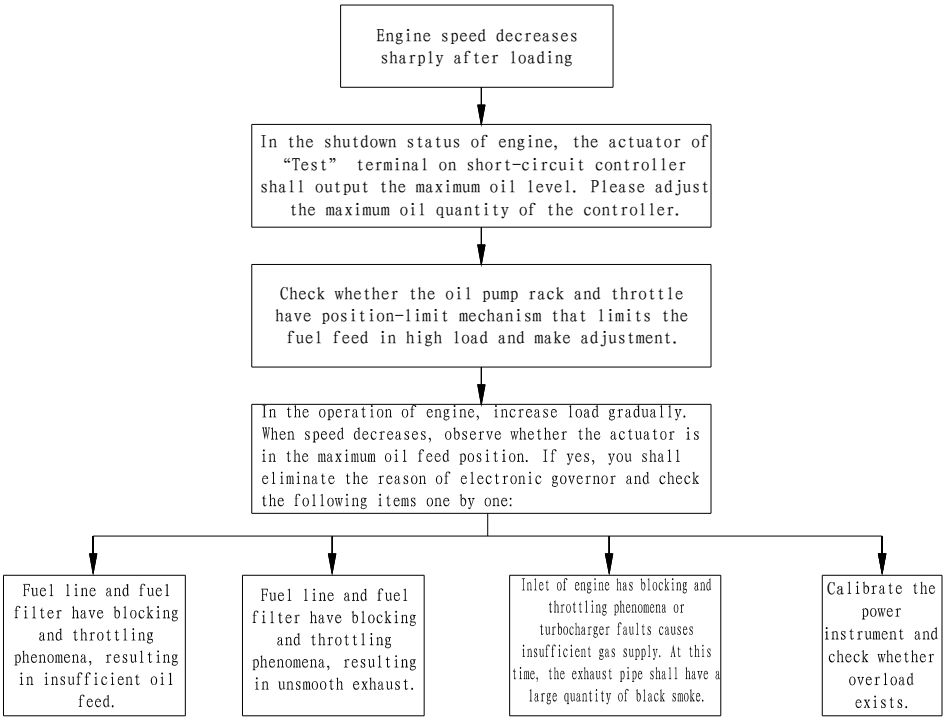


Figure 4.4 Engine speed decreases sharply after loading

4.1.5 Engine overspeed

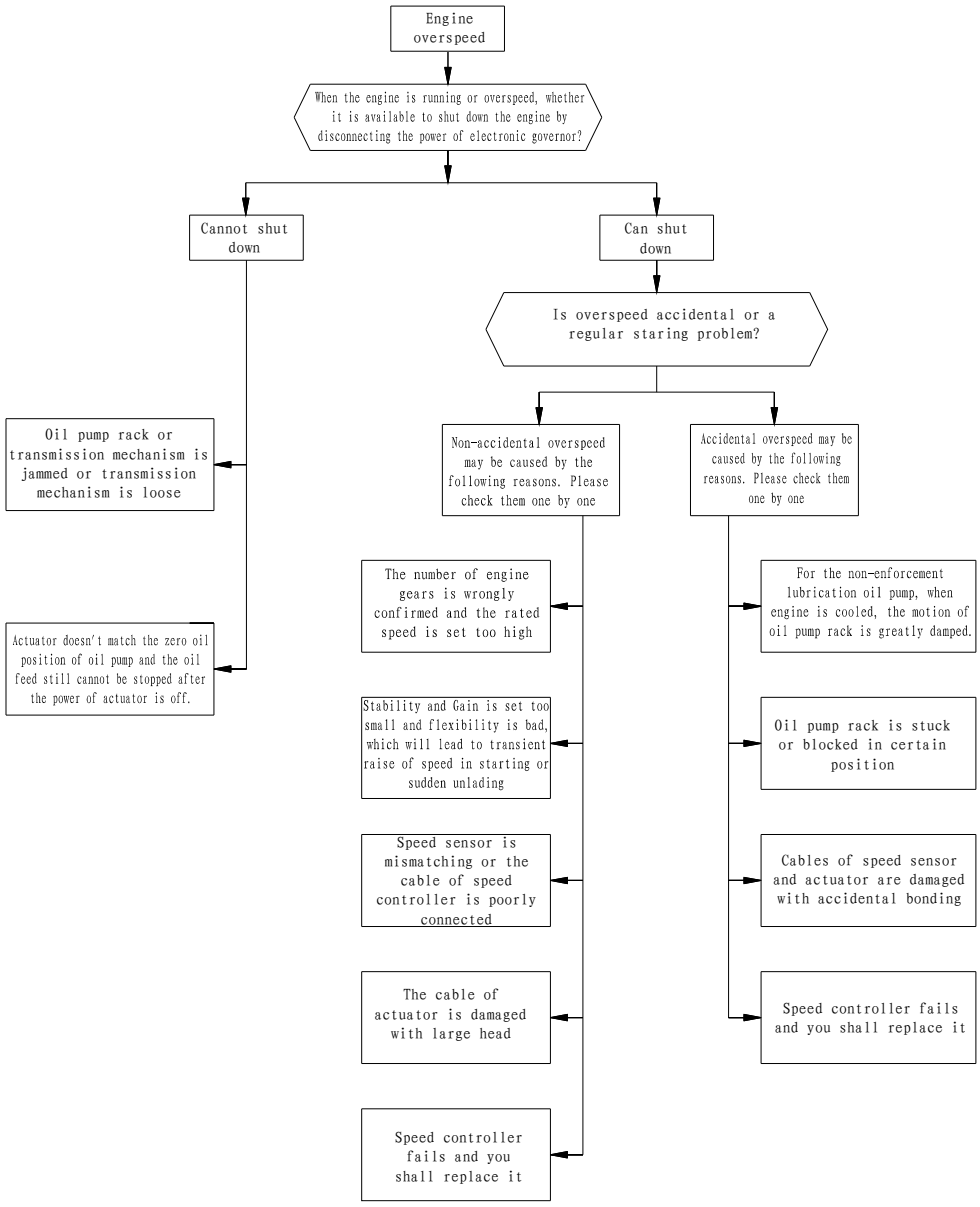


Figure 4.5 Engine overspeed

Note: If the trouble can't be solved after processed through the above mentioned ways and meanwhile, there is no trouble with the engine system, maybe it is the internal fault of the governor .Then you can send it to the maintenance department to repair .For the users who have no ability to maintenance, please don't dismantle blindly in case of expanding the fault.

4.2 Insufficient magnetic signal of the speed sensor

When the signal of the speed sensor is stronger, it can resist the external pulse interference; the speed sensor can measure the outputted signal which is more than 3V. When the signal of the speed sensor is less than

3V, you shall reduce the tooth gap between the speed sensor and the engine to improve the amplitude of the signal. The gap shall between 0.45~0.8mm. If the voltage is still less than 3V, you shall check whether the magnetism of the speed sensor is too weak.

4.3 Electromagnetic interference (EMI)

The electronic governor system can be adversely affected by large interfering signal that are introduced through the cabling or direct radiation into the control circuits. In order to avoid the medium interference, all the speed controllers produced include the filter unit and shielding designs that can protect the sensitive circuits against the external interference.

It is difficult and complicated to predict the value of the interference, you shall consider all the possible interference within the range such as radio communications of the space field, wireless walkie-talkie, wireless radio transmitter and the use of magneto, solid-state ignition system, voltage adjuster and battery chargers. When you doubt that the space field or the other systems will affect the operation of the governor by conduction or direct radiation during the using period, we suggest that you shall use the double-shielded cables as the external cables of the controller. And also ensure that one terminal of the shielded cable, including the shielded cable of speed sensor, 360 degree loop-connected to one supporting point on the enclosure of the speed governor, and then ground the metal plate of the governor or install it in a sealed metal box to avoid the electronic interference; There will be a better effect when using the metal cover or the metal container; It is the most common anti-interference measure to use the shielding wires. If using the generator with brush, you can't ignore the electronic spark interference, so you shall use the special shielding measure in huge interference environment; If you can't solve this kind of problems, please contact with our engineers who will give you some more suggestions.

5 Maintenance and Precautions

5.1 Maintenance of the electronic governor

5.1.1 Daily maintenance

- Please check whether there is something wrong with the cables and handle it timely. Cables arranged along the route shall be tied tightly to avoid cable shaking which may lead to the body friction; when laying out the cables, you shall keep the cables away from the high temperature parts (such as turbocharger, exhaust pipes etc.)
- Check whether the fasteners of the actuator are loose. If loose, you shall handle it timely.
- Check whether the actuator connector, sensor connector and the cable fastening screws have oil or become loose, and you shall make the corresponding treatment.
- Check whether the battery power is enough and the charging device is working smoothly.
- As to the non-enforcement lubrication oil pump, you shall check the high-pressure oil pump level and replace the lubricating oil timely.
- In the low temperature environment, you shall push the actuator arm by your hands several times; when you feel it running smoothly, you can start the engine.
- Observe whether there is oil leakage phenomenon on the actuator, if any, you shall replace the camshaft seal of the high pressure oil pump timely.

5.1.2 Maintenance for running 2000 hours

- There will be some dust in the probe site of the speed sensor, you shall remove and clean it up!
- Open the observation cover of the middle connect, check whether the connection fasteners and pins of the actuator and the pump rack are loosening or fall off.

5.1.3 Maintenance for running 6000 hours

- Remove the actuator from the high-pressure oil pump and check whether the pump rack is flexible.
- Check whether the high-pressure pump uniformity in the oil supply of each tank and injector atomization situation are normal on the oil pump check table.
- Change the speed sensor.
- For the forced lubrication oil pump, you shall replace the seal of high-pressure oil pump camshaft to ensure the lubricating oil won't leak to the actuator.

5.2 Application notes

- The speed sensor is solely used for the electronic governor produced by Our company and can't be used with other speed detection devices.
- To ensure the safety of the engine system, the speed-control function cannot replace the over-speed protection function of the electronic governor. You shall install the independent over-speed protection device.
- Every time before starting the engine, it is necessary to confirm whether the "IDLE/RATED" conversion switch is in the idle position.
- All the adjusting potentiometers of the controller have been preset. The non-professional people shall not adjust them arbitrarily
- You can't adjust (especially increase) the rated speed potentiometer setting and the speed trimming potentiometer when the engine shuts down to avoid the over-speed caused by the high speed setting when the engine starts.
- When you restart the engine after a long time of rest or under a low temperature environment, you shall push the actuator arms (or the tail shaft) by your hands several times firstly to make it run smoothly with no clamping phenomenon. If there is any clamping phenomenon, you can't start the enginee.